# POWER

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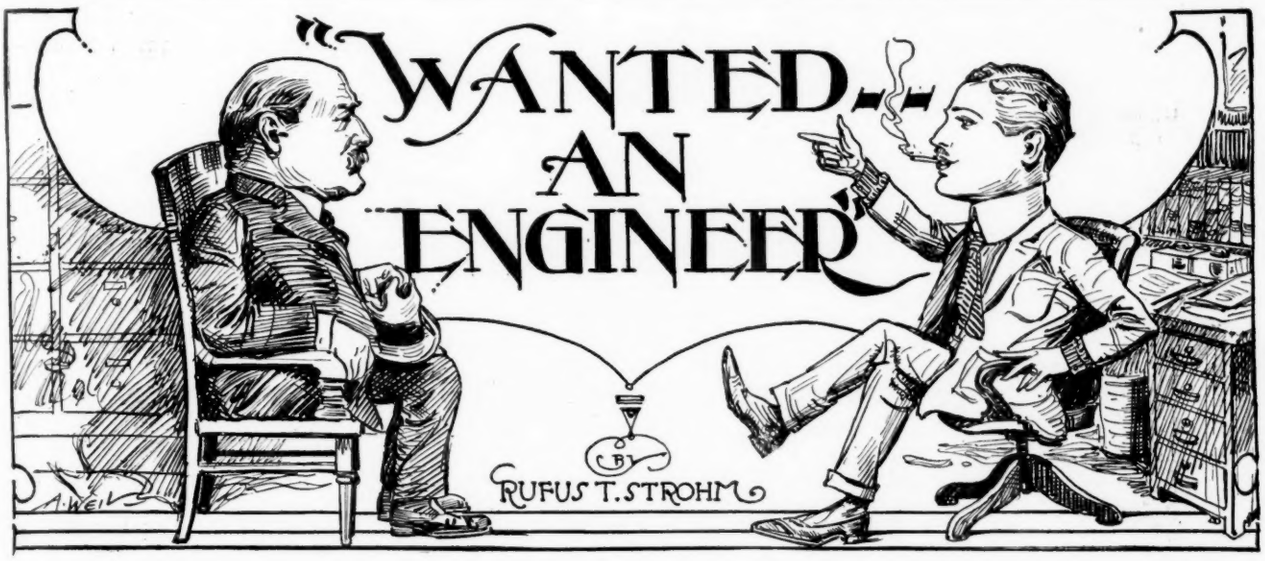



Blodgett pushed open the glass door marked "Superintendent" and confronted a young man wearing white flannels and an incipient mustache.

"I have come in answer to your advertisement," he explained.

"Sit down." The young man pushed a chair toward him. "You have had experience, I presume, in handling engines, boilers, dynamos and elevators," he remarked.

"Twenty-four years of it," Blodgett modestly admitted.

"Big plants or little?"

"Both." Blodgett could be as stingy of words as the other.

"Good," ejaculated the superintendent. "This is a big proposition and it requires a big man."

"Yes?" said Blodgett. "And what is the horsepower of your plant?" His voice was smooth.

The young man looked startled. He turned pink around the ears. The faint mustache grew tremulous.

"Why -- er—"

"The boiler horsepower, I mean," interjected Blodgett.

"Well—you see—I'm not a technical man," confessed the young man. "I'm a sort of efficiency manager." The repetition of the words seemed to restore his vanished poise.

"Then probably you can tell me," persisted Blodgett, "what boiler efficiency you are getting, or the evaporation per pound of coal."

"N-n-no," stammered the efficiency expert. "The chief engineer keeps all those figures." Then, as though fearing further embarrassing inquiries, he hastened to add: "Perhaps you'd like to know the duties of the position?"

Blodgett admitted that he would.

"You'd be expected to be here every morning at seven," said the dapper young man; "and that doesn't mean a quarter after or a minute after, but seven sharp."

"And how late would I have to remain?"

"Till seven—unless tenants were moving in or out. In that case you'd have to stick round till they had moved their safes or other heavy articles."

Blodgett made no comment, but waited for the superintendent to continue.

"You'd have to keep track of the time and the work of the scrub-women and see that the stairs and corridors were kept clean."

"But how about looking after the apparatus in the power plant?" A smile was beginning to form at the corners of Blodgett's eyes.

"Oh, of course that would be part of your job," exclaimed the young man. "But these other things belong—"

Blodgett interrupted by rising from his chair and putting on his hat.

"I am sorry to have wasted your time," he remarked in a level voice. "I understood from the ad that you were looking for a chief engineer. I see now that what you need is a head janitor. Good afternoon!"

# How to Make a Flue-Gas Analysis

By JOSEPH W. HAYS
Combustion Engineer, Chicago

*The author tells and shows just how to go about making an analysis of the flue gas. The article is intended for those who do not understand the use of the Orsat or gas-analyzing apparatus.*

THE sample of gas analyzed must be taken from the center of the gas stream through the open end of an ordinary black-iron pipe just after the gases leave the heating surface.

Drive a nail in the brickwork of the boiler setting at a convenient height and hang the gas-analysis instrument, Fig. 1, on it. Connect the instrument with the gas-sampling pipe by means of a rubber tube. There should be a cotton-waste filter at one end of the tube to keep soot and dirt out of the instrument. About midway of the tube is a bulb pump. The method of making an analysis will be better understood if reference is had to Figs. 2 and 3.

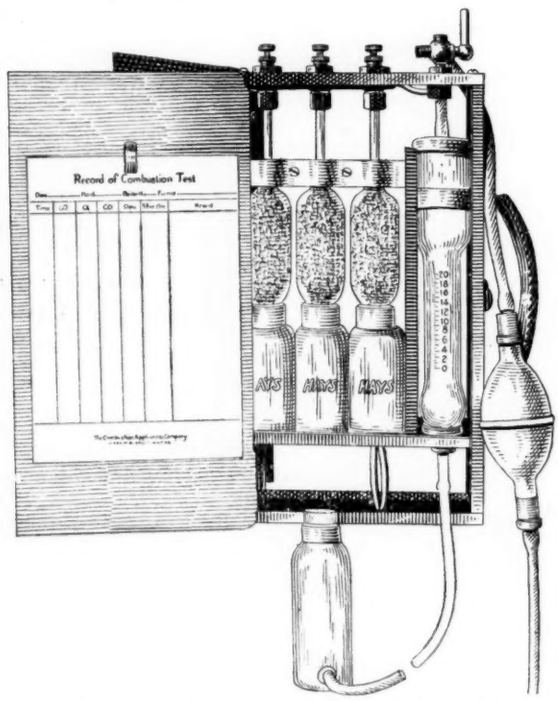
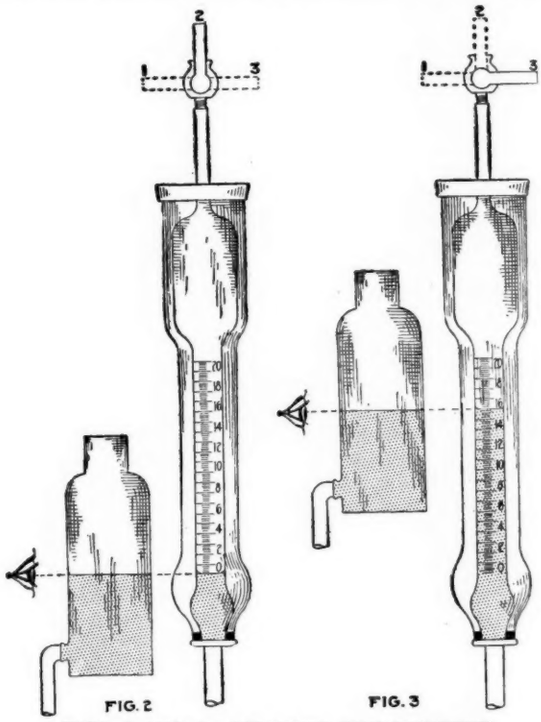



FIG. 1. READY FOR A GAS ANALYSIS

The first chamber at the left of the burette is charged with a solution of caustic alkali. The second chamber is commonly charged with a solution of pyrogallic acid mixed with a solution of caustic potash, and the third with a solution of cuprous chloride, either a hydrochloric acid or an ammoniacal solution, preferably the latter. The potash solution absorbs $CO_2$, the pyro-potash solution absorbs oxygen and the cuprous solution CO. Unfortunately, the pyro-potash solution will absorb both $CO_2$ and oxygen and the cuprous solution all three gases, so that in case of a mixture of $CO_2$, oxygen and CO, it is impossible to learn the ogygen percentage without first taking out the $CO_2$ or to learn the CO percentage without first removing both the $CO_2$ and the oxygen.

Make sure that the instrument is ready. The liquids should all be standing in the capillary tubes above the absorption bulbs. The leveling bottle should be filled with water and you should be prepared to note in writing all the readings that you may take from the instrument, together with the drafts being used when the samples were drawn, and a variety of other things.

You will note from Figs. 2 and 3 that there is a three-way cock above the burette. When the handle of the cock is in a horizontal position, pointing toward you, gas can be pumped through the burette and will bubble out of the leveling bottle. When the handle is in a vertical position, as shown in Fig. 2, the burette is open to the air, and when it is pointing away from you the cock is closed.




FIGS. 2 AND 3. READING THE BURETTE

With the handle of the cock in position 1 work the bulb pump with the hand and gas will be pumped through the instrument. It will take no more than five or six operations of the pump to flush out the tube and burette and fill the latter with gas.

The gas is now in the burette, but more of it than you require. Take the leveling bottle in the left hand and hold it close to the burette, steadying the hand against the instrument case. Get your eye into the position shown in Fig. 2 and turn the handle of the cock into position 2. Now, keeping your fingers on the handle of the cock, raise the leveling bottle until the surface of the water in the bottle is on a level with the zero mark on the burette. Water will flow from the bottle through the connecting tube into the burette and drive out the excess gas through the air vent of the gas-cock. Keep the surface of the water in the bottle in the same

horizontal plane with the zero mark. To do this you will have to raise the bottle slightly as the water flows out of it.

You will notice that the surface of the water in the burette is curved. When the bottom of this curve, or "meniscus," is on the zero mark, push the handle of the cock into position 3. You have now made a measurement of the gas at atmospheric pressure and the gas is at the temperature of the water in the jacket.

Making the first gas measurement is the most "ticklish" thing in connection with a gas analysis. You must not lower the leveling bottle when making a measurement, as this would cause water to flow from the burette back into the bottle and air would be drawn into the burette through the vent of the cock. This would spoil the gas sample and you would have to start all over again.

Having made the first measurement and locked the gas in the burette, you will find, if the leveling bottle is raised, that the gas is compressed and the volume diminishes and that if you lower the bottle the gas is rarefied and the volume increases. If you put the bottle on the zero mark, the water in the burette will return to zero. This experiment should show how important it is to be careful in making the original measurement and how necessary it is to make all measurements at atmospheric pressure.

### Removing the $CO_2$ from the Sample

The next step is to remove the $CO_2$ from the measured gas sample in the burette. Raise the leveling bottle with the left hand and turn the needle valve above the caustic container to the left. The gas will flow from the burette into the bulb of the container. Watch the water in the burette closely. You may push the gas over rapidly until the water nears the top of the bulb of the burette, when you should retard it with the leveling bottle and proceed slowly. When the water "pinches" out in the capillary tube above the burette, close the needle valve by turning it to the right.

The gas has now been transferred to the caustic container and you have removed the $CO_2$ from the mixture. The gas passes into the absorption bulb over fibers of steel wool which have been left wet with caustic by the displaced solution. The absorption is almost instantaneous and you can immediately return the gas to the burette.

Next, open the needle valve and lower the leveling bottle. Pay no attention to the water in the burette. Watch the caustic closely. You may bring the gas back rapidly until the caustic nears the top of the absorption bulb, when you must slow it up with the leveling bottle and bring the caustic up into the capillary tube. Stop the solution about midway of the tube and be careful that you do not draw any of it over into the burette.

Now bring your eye, the surface of the water in the leveling bottle and the bottom of the meniscus in the burette into the same horizontal plane, as shown in Fig. 3, and read the scale on the burette, reading on the bottom of the meniscus. Let the water in the burette come where it will. Bring your eye and the water in the bottle into line with it. The correctness of the analysis will depend largely upon the accuracy of your reading. The steel wool and the caustic have taken up all the $CO_2$ and the water jacket has taken care of the temperature. You must take care of the item of pressure and you must read the scale correctly.

The matter of leveling and reading the scale correctly is of the greatest importance when determining the percentages of oxygen and CO. Failure to get the eye into the same horizontal plane with the water levels may cause a serious error in the reading and lead you to conclude that there is no CO when it may in fact be present in a damaging quantity.

To take another gas sample for analysis, throw the handle of the cock into position 1 and work the aspirator bulb. The fresh gas will flush the stale gas out of the burette.

The absorptions of oxygen and CO proceed slowly, and care must be exercised in making the measurements. To determine the oxygen, you first make a memorandum of the $CO_2$ reading and then pass the gas into the middle container, which you have charged with the pyro solution. Allow the gas to remain there for about half a minute, then return to the burette and remeasure, noting the reading. Return again to the absorber container and repeat the operation until you get two readings that are exactly the same. You then proceed in like manner to absorb the CO.

### Oxygen Should Be Absorbed Before Trying for CO

Be sure that all the oxygen is absorbed before trying for the CO. Any oxygen that the pyro does not get will be absorbed by the cuprous solution, and you may think that CO is present when there is none whatever.

Some of the reports of flue-gas analysis that have been published are interesting only in that they show that an error was made in working or reading the gas-analysis instrument. When we have determined the percentages of the three gases, $CO_2$, oxygen and CO, we have accounted for all the oxygen in the air that was used. If the $CO_2$ plus the oxygen plus one-half the CO does not total close to 21 per cent., we can assume that the shortage in the totals is due to the hydrogen in the fuel; but if the discrepancy seems too great, it is best to assume that we have made a mistake and analyze another sample. In the case of high-hydrogen bituminous coals the sum of the $CO_2$, the oxygen and one-half the CO may not exceed 17 per cent.

The beginner will do well to confine himself to the $CO_2$ analysis until he knows the instrument well. Anybody almost can make a determination of $CO_2$. If a slight error is made in the reading it is not at all material, but there must be no errors when you analyze for the oxygen and CO.

And now that we know how to avoid mistakes in working the gas-analysis instrument, we can proceed with the combustion test. Spend an hour finding out what is the existing combustion efficiency. Spend another hour, or perhaps two, learning what to do to improve conditions. Learn how much $CO_2$ it is practicable to get and carry the load. Learn just how the coal should be fired or how the stokers should be operated. Many tests with the gas-analysis instrument must be made, many observations of the fire and many readings of the draft gage and pyrometer. It is a case of cutting and fitting and trying until we find the combination of operating conditions that will give that highly desirable result, the maximum of steam with the minimum of fuel. The next step is to get that result day in and day out in the everyday grind of plant operation.

# Conditions in the Power Industry

By LUDWIG W. SCHMIDT

*A digest of the reports of United States consuls on the power situation in various parts of the world and the influence of the war upon this important industry. Also see "Power," Oct. 1, 1918.*

THE withdrawal of men from English coal mines because of the war has necessitated closer attention to coal conservation in England. As a result, strict orders have been issued with the purpose of reducing the domestic coal consumption. To prevent consumers from going over from the burning of coal to the use of gas or electricity for heating purposes, the consumption of gas and electricity for domestic purposes also will be restricted. Fuel may be taken by the domestic consumer in the form of coal, gas or electricity. A system of distribution has been worked out according to which each ton of coal is represented by either 15,000 cu.ft. of gas or 800 Board of Trade units of electricity. It is left to the consumer to choose in what form he will take his allotment of fuel or power. By these means about nine million tons of coal will be saved and all fuel and power necessary for the industry can be provided (C. R. 176).[1]

### Record-Breaking Business in England

Central stations in England continue to be extremely busy, breaking all previous records. The Birmingham public utilities have sold during the last year 160,000,000 electrical units against 149,000,000 in the preceding year, the increase coming almost entirely from industrial consumers (C. R. 178). Sheffield also reports great activity. The Glasgow Corporation Electricity Department reports an increase in its revenue of a little over $1,000,000, while its working expenditures increased only $673,000. Like many other British cities, Glasgow has been compelled to charge higher rates for power and light, four cents being the present rate per unit for current equivalent to 1000 hours of the maximum demand and two cents per unit for over that quantity (C. R. 197). Bristol sold 26,839,580 units of electrical power against 23,000,000 the year before (C. R. 218).

Great efforts are being made all over England to extend the existing facilities for power production. Birmingham has just provided means for the construction of a new power station at Nechells. This plant will have a capacity of 30,000 kw., and nearly $6,700,000 will be required for the execution of the project. When ready, the new power plant will be linked up with the Smethwick plant. The situation in Birmingham is representative of the power situation over practically all of England. In 1913 it was thought that an expenditure of $1,300,000 would be sufficient to cover the outlay for the new plant that was then contemplated. Now a station nearly four times the size originally taken into consideration will replace the temporary structure which was built to relieve the strain upon the existing resources.

[1] C. R. indicates "Commerce Reports" of 1918.

Steps have been taken in Ireland to provide the island with a new power source. It is proposed to use the water power of the Liffey for this purpose. A dam increasing the fall of the Salmon Leap to about 40 ft. will be required for this scheme, by which a production of 2000 hp. during at least six months of the year can be obtained. The actual obtainable power development seems to be considerably higher, and as contracts for nearly 3000 hp. have been offered to the promoters of the enterprise, the question has been discussed whether by the use of Diesel engines a permanent development of 3000 hp. might be made possible. So far no decision seems to have been reached. Part of the power will be taken by the Dublin-Lucan Electric Railway Co., which is interested in the scheme, which is also supported by the Dublin Chamber of Commerce and the Dublin Corporation (C. R. 216).

### Reconstruction Work in France

Considerable progress is being made in France with the plans for a better utilization of the natural-power resources of that country for the rehabilitation of its industries. The first step to be taken is the reconstruction of the existing power and central stations in the still partly occupied territory. For its facilitation the Syndicat Professionel des Producteurs et Distributeurs d'Energie Electrique has been formed, which in turn has formed a subcommittee under the title of the Comptoir Central d'Achats Industriels pour les Regions Envahies. It appears that the productive capacity of all the power stations situated in the destroyed districts before the war amounted to about 300,000 kw. and it is estimated that at least 100,000 kw. will be required immediately after the evacuation of the country by the German armies.

Most of the equipment existing before the war has been destroyed and will have to be rebuilt. To hasten this work it is now proposed to standardize as much as possible the new plants so that they can be equipped without much loss of time. Standardization also will make it possible for the different power houses to exchange equipment if this should become necessary. A turbo-alternator group of 5000 kw. supplying three-phase current at 50 cycles per second at 10,500 volts will be used for that purpose, and 20 sets will be required to supply the first 100,000 kw. The first constructions, of course, will be more or less of a temporary character. The plants will be located where they are most urgently required and not where they existed before the war, if relocation should prove more advantageous. Also, no notice will be taken of the old distribution lines (C. R. 185). In the north, coal will be used as the principal source of power. In the south the waterfalls of the Alps and the Pyrenees may prove of considerable help to the electrical industry.

### Water-Power Development in Switzerland

Switzerland is busy with the completion of her vast scheme of developing the natural power of her waterfalls, which finally will render her independent of the supply of foreign coal. Zurich requires at present a

good deal of electric power, and the consumption would be much larger if a sufficient supply could be guaranteed. This is now contemplated by erecting a new power plant which, it is expected, will be ready in about three years (C. R. 192).

### Increase in Norway's Electrical Industry

Norway is still in the grip of a serious shortage of coal. Fortunately for its inhabitants, there is a sufficient supply of wood available which will have to replace coal this year. More coal is mined in Norway today than in former years, but the exceptional growth of Norwegian industries has produced such an enormous demand for power that even a considerable addition to the national coal production cannot meet the requirements. Approximately $9,000,000 was spent during the year 1917 in new enterprises of the metal and machinery industry, $4,000,000 was invested in new metallurgical enterprises, and nearly $6,000,000 in the chemical industry. Fortunately for the country, there has been a corresponding increase in the electrical industry in both the manufacturing and the power end. Nearly $2,000,000 was invested in the manufacture of electrical apparatus, and about the same amount has been spent for new power enterprises (C. R. 220).

The shortage of electrical power which has been felt severely in the southern parts of Norway will be relieved by the delivery of an additional 150,000 hp. from the Tysso Falls in the Hardanger district. The trunk line connecting the plant with Christiania is progressing favorably and may be finished during the next year, in which case 30,000 hp. will be made available immediately and a further 120,000 hp. will be developed as soon as possible. The total power available from the Tysso Falls is estimated at 2,750,000 hp., which will be completely developed in about three or four years. The total available horsepower in this neighborhood, which may be reached by way of the new trunk line, is estimated at between 4,000,000 and 5,000,000 hp., of which 1,500,000 hp. alone can be found in the Hardanger and Telemarken districts. The Christiania Electrical Works today own water rights amounting to approximately 400,000 hp. Work has been begun on the Raanaas Falls in the Glommen district, where the Akershus County Council develops 64,000 hp. at a cost of $5,000,000. The completion of the work will take about four years.

### Sweden Takes Up the Manufacture of Electrical Supplies

Sweden, which has been short of German supplies for several years, has taken up the manufacture of electrical goods on a larger scale. Swedish manufacturers today command the market for many electrical supplies that formerly were imported. The result may be a tendency for the Swedish legislature to give higher protection to the Swedish electrical industry after the war. This at least seems to be foreseen by the German Allgemeine Electricitats Gesellschaft, which is expending $2,000,000 for the erection in Sweden of a large factory for making electrical goods and appliances (C. R. 212).

Stringency in the supply of transmission materials is now seriously interfering with power construction in many countries. The building of power stations has been delayed in Australia, New Zealand and in many South American countries, and there are complaints even from South Africa. The result has been that orders for equipment are now frequently given to countries that in former years were able only to manufacture their own immediate consumption or even had to import. So it is reported from South Africa (C. R. 209) that negotiations have been opened with Japanese concerns for the supply of certain electrical equipment. Swedish firms also have entered the market.

A report by Consul James G. Carter of Tananarivo, Madagascar, says that the island at present has only two electric power plants. These are L'Energie Industrielle, Réseau de Madagascar, which supplies light and power to the City of Tananarivo, and Messrs. Barriquand & Orsini in Majunga, Madagascar (C. R. 203).

### New Foreign Capital Interests in South America

The war, by straining heavily the financial resources of the large industrial nations, which in former years have supplied most of the capital for electric power development in South America, has led to an increasing employment of capital resources which in pre-war times were rarely met in South America. Norwegian, Swedish and Hollandish capital has appeared and even Italy, although severely pressed for cash herself, has found means of doing some reorganization work in South America. It is reported from Asuncion, Paraguay, that the Asuncion Light and Power Co. has been purchased by the Italo-Argentina of Buenos Aires, a company financed by Italian and Swiss interests (C. R. 216).

Americans also are showing increasing interest in South American power properties. An American corporation has applied to the Venezuelan government for a concession covering the falls of the Caroni River near Ciudad Bolivar. It is estimated that a million horsepower can be generated on the spot without the erection of dams. For the present, however, development of about 100,000 hp. is intended, which will be used principally for mining operations (C. R. 176).

The increasing use of electric power by industrial consumers and householders has made it possible for the local central station in Cienfuegos, Cuba, to replace its night service for electric light with a continuous service during the whole day (C. R. 214). Cienfuegos in this respect follows the example of many Central American and West Indian cities, which have gone over from partial to continuous service during the last few years.

### Power Conditions in Japan and China

Japan reports a great activity in her electric power industry. During the month of April, 1918, the country had 597 power supply companies with a capital of $181,000,000, and there were 48 electric railroads that supplied part of their power to consumers. The total available water power amounts to 416,385 kw., of which 317,131 kw. is developed, and 118,968 kw. is generated by steam, to which 158,759 kw. soon will be added. Charters have been given to eight new establishments which will be put into operation as soon as possible (C. R. 205).

In China great efforts are being made to extend the electric-power supply facilities with a view to supplying power to the rapidly growing industries. The South

Manchuria Railway Co., which is a large power consumer and also distributes power to industrial and private consumers, has started a new power house west of the Japanese Settlement at Antung. The cost of the enterprise is estimated at $210,000 and two generators of 1000-kw. capacity will be installed. The company owns two other plants in the vicinity, but these have not been able to cope with the demand. At the present time there are 37 motors in use in industrial establishments in Antung, with a total development of 415 hp. The new plant, which will furnish power for a number of new industrial enterprises in the city, is expected to begin operation during December of the present year (C. R. 226).

Reference has previously been made in this series of articles to the fact that much of the new equipment bought by electric-power companies in China most likely is to come from American sources. According to a report by Consul General Thomas Sammons (Supplement to C. R. 52e) an order for the new 20,000-kw. turbo-alternator of the Municipal Council power plant of Shanghai has been placed with an American firm. The cost will be $457,000. "It was stated, in connection with placing this order, that a lower price might have been quoted on British products, but that the American machinery was considered more suitable and desirable even at a higher figure."

### Electric Light and Power Service in the Straits Settlements

The electric light and power service of the City of Penang, in the Straits Settlements, has suffered a good deal from the difficulty of obtaining the necessary materials for maintaining the service, but 302 new installations were made. The company has ordered an American electric locomotive to be supplied in the near future, which will be used for freight haulage. American exports of electrical goods to Siam have made very good progress since Germany, which in former years had the lion's share of the electrical business, ceased to participate in it. So far it seems that Japanese manufacturers have reaped the principal benefit, but English imports are beginning to increase again (C. R. 179).

## Triple-Blade Tube-Hole Cleaner

Cleaning the gasket bearing surfaces of the tube holes in the water-legs of water-tube boilers is a laborious task unless suitable means are employed. A

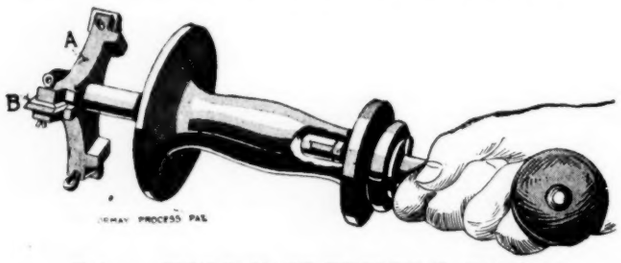



FIG. 1. TRIPLE-BLADE TUBE-HOLE CLEANER

little tool for quickly and efficiently doing this work is shown in Fig. 1.

This cleaner, which is made by John R. Robinson, 110 West 34th St., New York City, consists of a cutter head, a shaft to which it is attached, a handle, a roller and the cast-iron body, which is in the shape of a spindle. The cutter head *A*, Fig. 1, is made with three arms, in each of which is a tempered-steel blade *B*, having two cutting edges. This head is loosely secured to the shaft by a pin *C*, Fig. 3, so that the scraper blade can conform to the surface of the tube-plate header. A projection *D* from each arm of the cutter head fits into

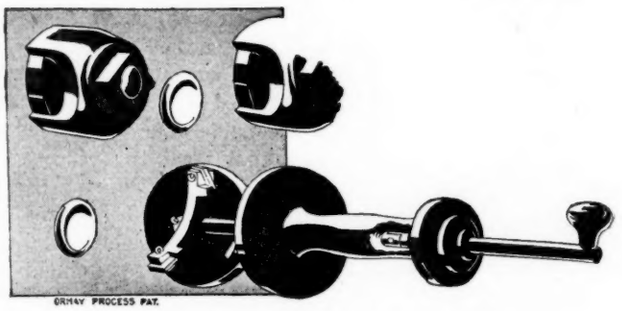


FIG. 2. INSERTING THE CLEANER

the cap opening to keep the tool head central. With the head in position the body is pushed up to the outside of the boiler header. Fig. 2 shows how the tool head is inserted in the hole. The joint *E* of the spindle is then brought out beyond the body of the spool, so that the handle end of the shaft can be turned at a right angle and thus form a crank, as at *F*, Fig. 3. This brings the

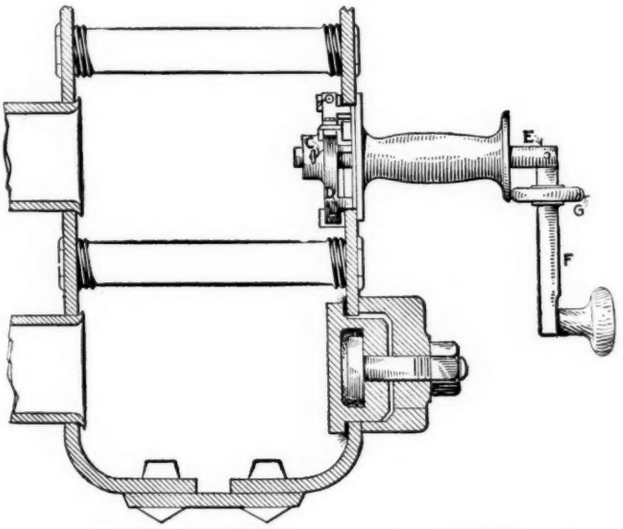



FIG. 3. CLEANER APPLIED TO A BOILER HEADER

roller *G* against the end of the spool and the harder the operator presses on the handle the harder the scraping blades bear against the inside or gasket surface that is to be cleaned. A few turns will remove all scale, leaving a clean surface for the new gasket.

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Argentina, as a result of the war, has been forced to seek the development of its own natural resources. It has been suggested that the government build an electric power plant at the Igazu Falls, for the purpose of solving the fuel problem. As these falls are among the highest in the world and about three times as wide as Niagara, it is estimated that millions of horsepower could be developed without detracting from their beauty.

# Care of Heating and Ventilating Equipment—V

By HAROLD L. ALT

*A general discussion of the relation of draft to the rate of combustion and the conditions influencing its intensity. The importance of correct breeching design and care in keeping all smoke passages clear is emphasized.*

SMOKE connections and chimneys have a most important and far-reaching effect and many operating difficulties would be smoothed away if proper draft were provided. And the most practical way to test the draft and rate at which coal can be burned in a given furnace is by turning on all the drafts and letting the boiler run for a period of two to four hours, wide open, allowing the surplus steam to escape through a temporary, valved relief pipe, then by weighing the coal used during the period and measuring the grate area the amount of coal burned per square foot per hour is found by the formula,

$$R = \frac{144 \times Lb}{H \times L \times W}$$

when

$R$ = Rate of combustion per square foot of grate per hour;
$Lb$ = Total weight of coal burned;
$H$ = Hours in which the coal is burned;
$L$ = Length of grate in inches;
$W$ = Width of grate in inches.

Thus if 360 lb. of coal is burned in a two-hour period on a grate 36 x 60 in., then

$$R = \frac{144 \times 360}{2 \times 60 \times 36} = 12 \text{ lb. per sq.ft. per hour.}$$

When carrying their full load, heating boilers are designed to burn coal at the rate of from 5 lb. in the smallest sizes up to 15 lb. or over per square foot of grate area in the largest sizes. This wide variation occurs because most of the smaller boilers are built to suit periodical firing periods of greater or less frequency, while the large boilers presuppose the attendance of a fireman constantly so that infrequent firing does not limit their combustion. A boiler fired only once in four hours must have a large grate, deep firebox and operate at a low combustion rate to avoid burning out the fuel before the end of the four-hour period, while if the firing interval is made shorter the fuel can be burned as fast as the available draft will permit. Therefore, if the coal burns at too low a rate while conducting the test, it shows that the draft is not sufficient and should be increased.

There has been a great deal of discussion from time to time regarding the efficiency of a low combustion rate and the heat losses in the chimney due to the high temperature of the gases which result from forcing the fire. It has been proved by experiment that the amount of water evaporated per pound of coal burned is greater at a higher combustion rate (7 to 9 lb. per sq.ft.) than at the lower rate (3 to 6 lb. per sq.ft.). This is probably due to better combustion with a hot fire and an increase in radiant heat. In regard to the amount of draft available, there is one factor that helps out a heating plant considerably; namely, the fact that the time of greatest load occurs during periods of low temperature or high wind. As the stack draft is dependent upon the temperature difference between the gas inside the stack and the air outside, the hotter the gases and the colder the air the more intense the draft. High winds also facilitate stack action.

## Heating Boilers Seldom Overloaded

A heating plant is seldom run at overload; in fact, many heating experts specify boilers anywhere from 25 to 50 per cent. above the actual maximum load. This means that if a heating boiler is to be connected to a load of 10,000 sq.ft. of equivalent direct radiation, the boiler used would be rated at 12,500 to 15,000 sq.ft. If the boiler really can carry 100 per cent. of its rated load, then during the heating season (the mean load being about one-half the maximum) the average load on the boiler would be about 5000 sq.ft., or 33 to 40 per cent. only.

Modern practice is getting away from rating trouble to some extent—especially in steel boilers—by assuming that 100 sq.ft. of equivalent direct radiation (exclusive of piping) requires 10 sq.ft. of heating surface and 0.2 to 0.3 sq.ft. of grate area. This is based on the fact that every square foot of direct steam radiation condenses about ¼ lb. of steam per hour, and including the pipe losses this increases to ⅓ lb., so that 100 sq.ft. of radiation condenses 33 lb. of steam per hour, which is about equal to one boiler horsepower under the conditions usually attained in heating plants; namely, producing steam at 5 lb. maximum gage pressure. As 10 sq.ft. of heating surface equals about one boiler hp., then 100 sq.ft. of radiation approximates a heating requirement equal to the amount of steam furnished by 10 sq.ft. of boiler-heating surface, and at 0.2 to 0.3 sq.ft. of grate area per boiler horsepower each square foot of grate must supply 3⅓ to 5 boiler horsepower. At four pounds of coal per boiler horsepower this is 13 to 20 lb. per sq.ft. of grate.

## Flue-Cleaning Should Be Done in Spring

The smoke breeching and uptake should be kept clean, yet many engineers close down heating boilers in the spring, leaving the flue uncleaned, thinking that there will be plenty of time in the fall, and in the fall find themselves too busy. The proper time for flue cleaning is in the spring after the heating season is over. Allowing soot to remain in steel smoke pipes all summer has two disadvantages; it becomes damp and cakes or hardens and at the same time the sulphur it contains attacks the iron of the pipe and corrodes it rapidly.

There is considerable variation in practice among manufacturers of low-pressure boilers as to how large the smoke pipes should be; but 0.035 sq.ft. per 100 sq.ft. of radiation, or per boiler horsepower, is large enough to guarantee against bad results. To reduce friction a round shape is the best, square next and oblong the worst, and in no case should the long dimension of an oblong flue be more than twice the short dimen-

sion. A steel flue, unlined, is better for draft than a masonry flue owing to its smooth surface, but the radiation from and deterioration of steel is much greater. Some of the features which commonly interfere with draft and therefore prevent getting good results consist of too small a smoke pipe, sharp turns and corners, breeching too far into the chimney and obstructions of all kinds. The practice of making square turns in the breeching is bad especially where the draft is poor. Where the draft is excessive such turns do not matter, but there is no logical reason why they should ever be used even then. It is not at all uncommon to see boilers connected up to the chimney as illustrated in Fig. 1. Still worse is the common practice of building breechings so that the gas from one boiler or battery butts against the flow from the other, as shown in Fig. 2. This results in a regular head-on collision and gas eddies, in the midst of which the gases must make a right-angle turn into the stack. A much easier flow of flue gases will be obtained with connection arranged as shown in Fig. 3. Quite a common error is running the smoke pipe too far into the chimney, as indicated in Fig. 4. This interferes with the draft in a positive manner, but has the advantage of being easily remedied after the trouble has been located. Leaks into the smoke pipe or around its entrance into the chimney will spoil a draft that otherwise would be perfectly satisfactory. The friction through these openings, admitting air without passing through the fire, is much less and therefore a small opening will admit a lot of air. Air leakage through brick setting affects the draft in the same manner. A little plastic asbestos applied to such openings will usually form a good temporary first-aid until permanent repairs can be made. In renewing or repairing the smoke flue it should be remembered that no obstructions should be placed on the inside of the flue. Extra angles, bracing, etc., must all be placed on the outside and the gas passage kept as smooth and straight as possible.

### Stack Must Be Adequate in Size and Height

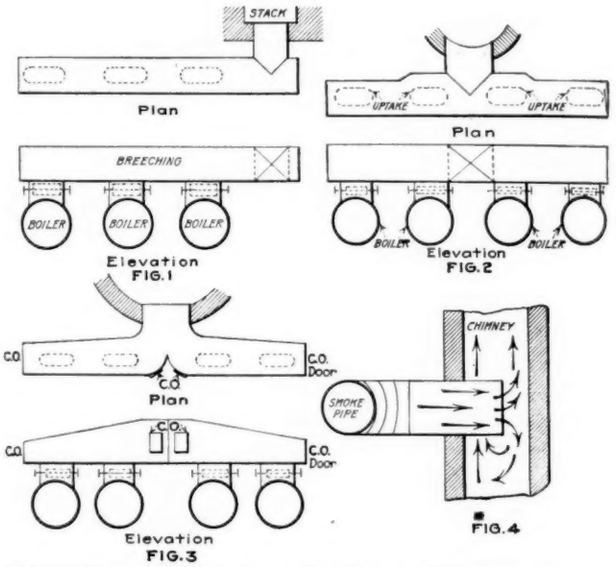
In addition to the foregoing the stack must be large enough to care for the volume of gases during the time of maximum load and it must be high enough to produce the intensity necessary to burn the coal at the required rate. In general the chimney should be as high or higher than any building within fifty feet. The schedule shown in Table I has been used with success in several hundred cases and may be accepted as reasonably correct.

TABLE I. STACK PROPORTIONS FOR GIVEN BOILERS

| Capacity of Boiler, Square Feet of Radiation | Square Flue, Inches on Side | Round Flue, Inches Diameter | Height, Feet |
|---|---|---|---|
| Up to 500 | 9 | 10 | 40 |
| 500– 1,000 | 12 | 13 | 45 |
| 1,000– 1,500 | 12 | 13 | 50 |
| 1,500– 2,500 | 16 | 17 | 60 |
| 2,500– 3,000 | 20 | 22 | 60 |
| 3,000– 3,800 | 20 | 22 | 70 |
| 3,800– 4,200 | 20 | 22 | 75 |
| 4,200– 6,500 | 24 | 26 | 75 |
| 6,500– 8,750 | 24 | 26 | 80 |
| 8,750–10,000 | 28 | 30 | 80 |
| 10,000–10,500 | 32 | 34 | 80 |
| 10,500–13,000 | 32 | 34 | 90 |
| 13,000–14,000 | 36 | 38 | 90 |
| 14,000–14,500 | 36 | 38 | 95 |
| 14,500–15,000 | 36 | 38 | 100 |

Table I assumes the smoke outlet of the boiler is not set more than ten feet from the stack and allows for one right-angle turn in the breeching. For every additional right-angle turn add ten feet to the stack height. While some manufacturers claim that boilers of small size will operate on 40-ft. stacks, it is much safer to use a stack at least 60 ft. high for down-draft boilers of any size and to increase the height as the rate of combustion goes over 10 lb. per sq.ft. of grate area.

It is necessary to bear in mind the difference between volume and intensity of draft. If a water faucet is opened full, a good volume of flow is obtained usually with very little pressure because the outlet of the faucet is unobstructed; but if the finger is held over the outlet so as to partly obstruct it, a fine stream of high intensity results, even though the actual volume is considerably less. Similarly with a chimney—a large low stack will handle a large volume at very low intensity and a slender high stack will handle a small volume at a much higher intensity. The quantity of coal burned per hour determines the volume of gas the stack is called upon to handle, and the thickness of fire, friction of gases, elbows, dampers, etc., determine the intensity necessary.




FIGS. 1 TO 4. GOOD AND BAD SMOKE BREECHING DESIGN

Figs. 1 and 2—Examples of bad breeching design. Fig. 3—Breeching with easy turns and increasing sectional area. Fig. 4—Smoke-pipe extended too far into chimney.

The draft loss through the fire varies about as shown in Table II for the various rates of combustion shown.

TABLE II. APPROXIMATE DRAFT LOSS THROUGH FIRE

| | Pounds of Coal Burned per Sq.Ft. of Grate per Hour | | | | |
|---|---|---|---|---|---|
| | 5 | 10 | 15 | 20 | 25 |
| | Draft Loss in Inches of Water Gage | | | | |
| **Anthracite:** | | | | | |
| No. 3 Buckwheat | 0.15 | 0.40 | 0.75 | 1.24 | |
| No. 1 Buckwheat | 0.10 | 0.24 | 0.44 | 0.68 | 1.00 |
| Pea | 0.06 | 0.16 | 0.30 | 0.45 | 0.65 |
| **Bituminous:** | | | | | |
| Semibituminous | 0.05 | 0.10 | 0.18 | 0.26 | 0.35 |
| Penn., Ill., Ala., and Ind. | 0.04 | 0.09 | 0.15 | 0.22 | 0.28 |
| Slack | 0.04 | 0.07 | 0.10 | 0.15 | 0.20 |
| Run-of-mine | 0.04 | 0.05 | 0.08 | 0.10 | 0.14 |
| Chain grate | 0.05 | 0.12 | 0.15 | 0.23 | 0.31 |

Added to the losses shown in Table II is the loss in the boiler flues, which for a horizontal return-tubular boiler at full load is about 0.2 in. of water; for cast-iron sectional boilers with fewer passes and larger flues the loss will be somewhat less. In the breeching (steel) the loss will be about 0.1 in. per hundred lineal feet plus 0.05 in. for each right-angle turn from the boiler

up to and including the turn-up at the base of the stack. Thus it will be seen that the loss from the ashpit to the stack will be $0.10 + 0.2 + \left(0.1 \times \frac{25}{100}\right) + (0.05 \times 4)$ or 0.52 in. burning run-of-mine coal at the rate of 20 lb. per sq.ft. of grate and allowing for 25 ft. of flue and four bends. These losses are shown graphically in Fig. 5 and should not be exceeded for similar conditions. Of course where the combustion rate or kind of coal burned is different, the proper draft loss must be substituted. The draft loss through the fuel bed or

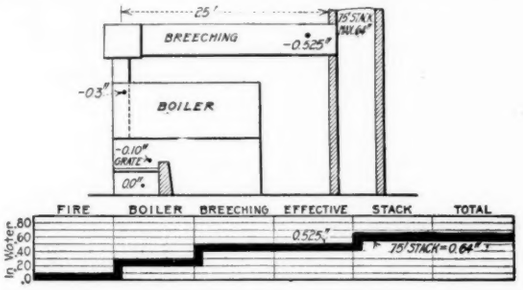



FIG. 5. LOSS OF DRAFT FROM ASHPIT TO STACK

boiler is easily ascertained by taking a reading at two points, the difference between the two readings being the draft loss between the two points. If this exceeds the proper amount, investigation should be made to determine the cause.

Air leaks into the stack itself will cause a loss of draft so that the draft reading at the base of stack will be less than it should be to correspond with the height and average stack temperature. The theoretical draft for the mean stack temperature of 500 deg. F. is given in Table III.

TABLE III. THEORETICAL STACK DRAFT

| Altitude | Height of Stack in Feet | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 50 | 60 | 70 | 80 | 90 | 100 | 125 | 150 |
| | Theoretical Draft, Inches of Water | | | | | | | |
| Sea level | 0.45 | 0.53 | 0.60 | 0.70 | 0.80 | 0.88 | 1.10 | 1.30 |
| 2,000 feet | 0.40 | 0.50 | 0.56 | 0.65 | 0.72 | 0.80 | 1.00 | 1.20 |
| 3,000 feet | 0.37 | 0.45 | 0.53 | 0.60 | 0.66 | 0.75 | 0.91 | 1.10 |
| 6,000 feet | 0.35 | 0.40 | 0.48 | 0.55 | 0.60 | 0.70 | 0.85 | 1.02 |

The average stack temperature can most easily be obtained by lowering a thermometer a short distance down from the top of the stack and averaging its reading with one at the base, or, better, insert a thermometer at a point halfway up the stack. Owing to friction in the stack itself the draft reading at the base will be 0.1 to 0.3 in. less per 100 ft. of stack height. Thus for a 60-ft. stack the effective draft at the base will be the theoretical draft minus $\frac{60 \times 0.1}{100}$ to $\frac{60 \times 0.3}{100}$, or 0.06 to 0.18 in. less than the theoretical draft. Excessive leakage in the stack not only operates as an overload on the stack, but also cools the gases and thus lowers the average stack temperature.

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According to the United States Fuel Administration, the waste of natural gas in a group of Missouri and Kansas cities and towns amounts to from twenty-three to seventy-three per cent. The gas delivered to them has an estimated value of around nineteen million dollars. Had conservation been practised it is estimated that these cities and towns could have had natural gas at fifty cents per thousand cubic feet for twenty years.

## Marking or Altering Blueprints

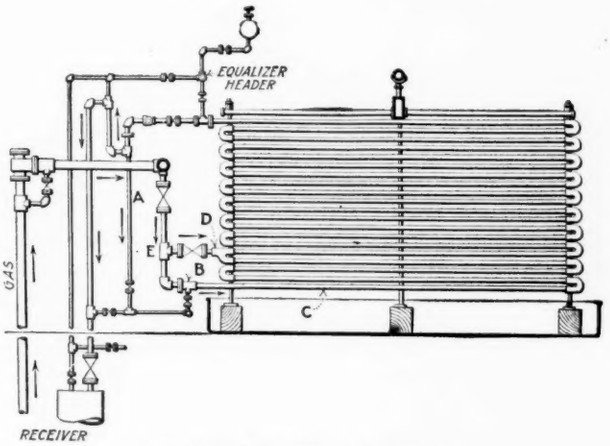
BY M. A. SALLER

It is often desirable to remove the blue color from blueprints when it is necessary to obliterate some portion of the blueprint or to print in additional details with black drawing ink, which does not stand out prominently on blue paper. A solution for readily bleaching out the blue color can be made by dissolving in water a small quantity of sodium carbonate or "soda ash" and applying it to the print by means of a small brush, when the blue color will disappear almost immediately.

This solution may also be used to extend the white lines on any portion of the print. When it is applied with an ordinary drawing pen, it will produce a fine hair line which closely resembles the white printed lines.

## Block Condenser Improved

The following relates to improvements to the condenser invented by Louis Block, consulting engineer, New York City. Liquid ammonia in regulated quantities is admitted with the hot gas to the bottom pipe of the condenser, the liquid coming down pipe *A* and passing into the fitting *B*, where it meets the gas and from which both pass at high velocity into the bottom pipe *C* of the condenser. The velocity is sufficient to drive the gas and liquid to the top of the condenser. This insures that the condenser has the maximum quantity of liquid throughout. The fitting *B* is provided with nozzles which extend but a short distance into the fitting, and their function is to inject gas into the condenser. These nozzles are adapted to regulate the




IMPROVED BLOCK CONDENSER

amount of gas to various coils in a large condenser and thus tend to promote uniform distribution of the gas to all coils.

A special elbow *D* on the fourth and fifth pipes from the bottom connect with the hot gas line *E*, so that hot gases may be admitted above the bottom of the condenser. The inventor intends that nozzles similar to those in *B* be used on all gas and liquid inlets for the purpose of regulation. Some improvements also have been made in the connections for pumping out and isolating unit coils of the condenser. The purpose, of course, is to increase the rate of heat transmission.

# Combustion in Its Relation to Boilers

By E. A. UEHLING

THIS ARTICLE INDORSED BY

U. S. FUEL ADMINISTRATION

*Fuel saving is easier if the fireman understands the process of combustion. This article describes the requirements for complete combustion and discusses combustion efficiency and absorption efficiency.*

COMBUSTION in the ordinary sense is the chemical reaction between the oxygen of the air and the combustible elements of fuel, and is due to the affinity of the former for the latter. This affinity, however, is dormant at the lower temperatures and does not become active unless energized by a comparatively high temperature. Thus, heat as well as oxygen is required to start and support combustion, and combustion is the effect as well as the cause of heat.

Excepting spontaneous combustion, which does not come within the scope of our treatment of the subject, the heat required to energize the chemical affinity between the oxygen and the combustible elements of the fuel to start combustion must be supplied from an outside source. The source may be electrical, as when the charge of an internal-combustion engine is ignited by an electric spark, or it may be physical, as when a gas jet is ignited by a piece of platinum gauze or sponge; but as a general thing the source of this initial energizing heat is mechanical, that is, mechanical force converted into heat by friction.

The Indians produced it by rubbing together two sticks of dry wood until they got so hot that they ignited. The Europeans did it by striking a piece of steel against a flint. We now do it by rubbing a match against a rough surface. In all cases the immediate source of heat required to ignite a fire is friction. When once started under proper conditions, combustion continues until the combustibles contained in the fuel are consumed or the supply of oxygen is cut off, or the temperature, from whatever cause, is reduced below the point of ignition.

## Complete Combustion

Complete combustion liberates all the heat contained in the coal. Every operating engineer should know the heating value of the coal he is burning; but even if he does not know exactly, it is up to him to get it all out. To do this he must see to it that the coal is completely burned. The requirements for complete combustion are four in number: (1) Excess air (oxygen); (2) high temperature in the furnace and combustion chamber; (3) intimate and uniform mixture of the air with the combustibles; and (4) time. One pound of carbon requires for its complete combustion 11.6 lb., or 152 cu.ft., of air at 62 deg. F. To burn one pound of hydrogen 34.8 lb., or 457 cu.ft., of air is required. Just how much air one pound of coal will require for complete combustion depends upon its composition.

Complete combustion with the theoretical amount of air is not possible under the conditions imposed by practice. The mixture of air and combustibles is never perfect, the combustion space is limited, and the temperature and time necessary for all the oxygen to come in contact and combine with every element of the combustibles are not realized in practice. An excess of air is therefore necessary. Excess air increases the opportunity for every molecule of oxygen ($O_2$) to come in contact with an atom of carbon (C) and combine to form $CO_2$, and every molecule of hydrogen ($H_2$) to find and combine with an atom of oxygen (O) and form $H_2O$; but unless the air and the combustible elements of the fuel are intimately mingled, complete combustion will not result, no matter how much excess air is supplied.

Too great an excess of air militates against complete combustion, because it reduces the furnace temperature and also the time that the gases remain in the combustion chamber. When the gases enter or get among the comparatively cold boiler tubes, the temperature is rapidly reduced below the point of ignition, and unless combustion is complete before the flame comes in close contact with the boiler surface, CO and other unconsumed combustible gases will escape, together with unburned carbon (soot).

## Quantity of Excess Air Required

The amount of excess air necessary to insure complete combustion depends on the construction of the furnace, the kind and quality of the fuel used and the method of stoking. Under favorable circumstances complete combustion has been attained with as little as 12 per cent. of excess air; but it is not advisable to go below 20 per cent. even in furnaces best adapted to get complete combustion with the kind of fuel used.

Fuel containing a high percentage of volatile matter requires more excess air than one low in volatile matter, but in no case should it be necessary to use more than 50 per cent. of excess air. If complete combustion cannot be secured with 50 per cent., or at most 60 per cent., of excess air, there is something wrong with the furnace or the plant in general; yet 100 per cent. of excess air is nearer the average used, 200 per cent. is frequent, and boilers using 300 per cent. and more are by no means rare. As a rule, furnaces served by underfeed stokers require less excess air than overfeed or hand-fired furnaces.

Time and high temperature are the most important factors in securing complete combustion. All other conditions remaining the same, the longer the mixture of air and combustible can remain in the combustion chamber the less the excess air required; hence, a large combustion chamber is conducive to complete combustion. The hotter the furnace the more vigorous and rapid is the combustion; therefore the time required for complete combustion is less as the temperature is higher.

Excess air facilitates combustion inasmuch as it increases the oxygen available to the fuel elements; but too great an amount is a handicap to complete combustion. All excess air must be heated to the temperature of the furnace; so, the greater the excess of air supplied the lower will be the furnace temperature, and

the lower the furnace temperature the greater the time required to complete combustion. Again, the greater the amount of excess air the greater will be the volume of the gases per pound of fuel burned, and for the same rate of combustion the time that the mixture of air and combustible gases can remain in the combustion chamber must decrease as the volume of excess air increases. Thus, both of the two most important factors necessary to the securing of complete combustion are adversely affected by an undue excess of air.

The slower the rate of driving the greater the time available for complete combustion, and so slow driving is conducive to complete combustion; but since the furnace temperature decreases with the rate of driving, a limit is soon reached where slow driving becomes a handicap to complete combustion. Complete combustion does not take place in a smoldering fire. The greater the rate of driving the higher the furnace temperature, and so a high rate of driving is also conducive to complete combustion; but the greater the rate of driving the shorter the time available for the process of combustion, and that sets a limit to fast driving with complete combustion. There is therefore a lower as well as an upper limit of driving beyond which complete combustion will not result. For reasons already sufficiently explained, the range between these limits becomes smaller as the percentage of excess air is increased. The range is greatest when the mixture of air and combustible is most thorough and the excess air closely approaches the minimum required. The upper limit can be extended by enlarging the combustion chamber, and the lower by providing against radiation.

## Efficient Combustion

Efficient combustion results when the fuel is burned completely with the minimum amount of excess air and no further air is allowed to admix after combustion is completed. Complete combustion liberates all the heat contained in the fuel, but efficient combustion requires that the heat be liberated in such a manner that it can give the maximum useful effect. Combustion efficiency is, therefore, the ratio of the heat available to the heat contained in the fuel; that is,

$$\textit{Combustion efficiency} = \frac{\textit{heat available for making steam}}{\textit{heat contained in fuel burned}}$$

In the application of heat to a boiler the available heat is the difference between the quantity of heat contained in the fuel and that contained in the gases escaping at the temperature of the water in the boiler. The quantity of heat produced per pound of fuel burned is independent of the amount of excess air used; therefore, the less the weight of gas per pound of fuel burned the greater will be the quantity of heat available for the boiler. The weight of the gas produced equals the weight of the combustible consumed plus the weight of the air used; consequently, the smaller the weight of air used to secure complete combustion the greater will be the combustion efficiency.

If the combustion should proceed so slowly or with such an excess of air that the furnace temperature did not materially exceed the temperature of the water in the boiler, there would be no heat available to the boiler and the combustion efficiency would be zero. It is evident, then, that the higher the furnace temperature the better will be the combustion efficiency, provided that combustion is practically complete and no air is permitted to enter the setting beyond the combustion chamber.

It has been shown that high furnace temperature is also conducive to complete combustion; therefore the first principle in the utilization of the heat of combustion is to burn the fuel at the highest practicable temperature that the structural, operating and fuel conditions of the plant will permit, which implies burning the coal completely with a minimum of excess air.

## Absorption Efficiency

The heat contained in the fuel is liberated in the furnace by the chemical process of combustion, transmitted to the water in the boiler by absorption and transformed into steam by the process of evaporation. By these processes the chemical energy stored in the fuel is changed into physical energy stored in steam under pressure. The percentage of the chemical energy stored in the fuel that can be transformed into steam depends on the efficiency of combustion and on the efficiency of absorption. Absorption efficiency is the ratio of the heat contained in the steam generated to the heat available for making steam; that is,

$$\textit{Absorption efficiency} = \frac{\textit{heat in steam generated}}{\textit{heat available for making steam}}$$

Absorption efficiency depends on (1) the condition of the heating surface, (2) proper baffling and (3) the rate of driving. High efficiency demands that the heating surface be kept clean both inside and out. The gases must be so conducted through the boiler that they come in contact with all the heating surface, and the baffling must be kept intact to prevent short cuts. There is a lower as well as an upper limit to the rate of driving beyond which efficiency suffers. The range of efficient driving depends on the type of boiler, the construction of the furnace and the method of stoking. Water-tube boilers as a rule permit a higher rate of driving than fire-tube boilers.

The larger the combustion chamber the higher the rate of driving permissible, and stoker-fed boilers can be driven faster than hand-fired. Very moderate driving, as well as excessive driving, results in reduced economy.

## Boiler Efficiency

Boiler efficiency is the ratio of the heat output to the heat input. The heat input is taken as the total heat contained in the coal, and in order to make the results of all boiler tests comparable, the heat output is based on the heat contained in saturated steam evaporated from and at 212 deg. F. Boiler efficiency depends primarily on combustion efficiency and secondarily on absorption efficiency. The fireman must look out for the former and the boiler cleaner for the latter, but the engineer is responsible for both, and it is up to the manager to procure the necessary instruments to diagnose and control the operation of the boilers intelligently and effectively.

The manager may or may not know what equipment is necessary. He may be too busy or lack the technical knowledge to investigate all the available instruments and apparatus and to discriminate between those merely

desirable and more or less useful and those necessary. It is not his duty to look after every detail, and generally it is not possible for him to do so without neglecting larger matters.

It is up to the engineer to look after the details of his department, to keep himself posted on the progress of his profession and do his best to raise it to a higher and more scientific level. It is up to him to familiarize himself with the functions of all available scientific instruments as well as the mechanical appliances that will aid him in his work. He should be able to distinguish between the things merely desirable and those absolutely necessary. Having decided what is necessary, he must bring his needs to the attention of the manager and persist in asking for what he wants—diplomatically if necessary—until he gets it.

# Steam-Header Pointers

By M. A. Saller

THE design and construction of steam headers involves not only receiving steam from the boilers and passing it along to the engines, but headroom, size or capacity, expansion and anchorage, drainage, covering, method of taking off connections, branches, etc. The header should not only act as a steam connection, but also serve to some extent as a receiver to equalize the pressures and to counteract the effect of any momentary heavy demand for steam. The size of the header will depend, of course, on the velocity of steam desired. The velocity for saturated steam averages about 6000 ft. per min. when reciprocating engines are used, but where the steam has a steady flow through the line without pulsations, as in the case of a turbine, or when used for heating or industrial purposes, the velocity may safely be as high as 8000 or 9000 ft. per min. Where large receivers are provided near each engine, the steam velocity to the engine may be increased to 7000 ft. per min. Advocates of high velocity maintain that in all cases economy dictates velocities 25 to 33 per cent. higher than those given. A good rule, however, is to make the steam-header area equal to the sum of the area of the full-size boiler outlet, and this can be followed to advantage in all except complicated layouts, where a special study of the conditions and capacities is necessary, or in the case of extremely long headers where there is no possibility of the header having to pass the full quantity of steam generated by the boilers, in which case a smaller size can be used. But as stated, some engineers use a header only slightly larger than the diameter of the maximum boiler outlet and then provide receivers on each engine with capacity of from two to four cylinderfuls of steam to take care of pulsations and to act as a steam reservoir close to the throttle. Unless too long, the header should be made the same diameter throughout to facilitate drainage and to prevent forming water pockets.

Connections to and from the header should be as short and direct as possible consistent with proper provision for expansion, and sharp turns should be avoided. The line from each boiler to the header should be fitted with a stop valve and also with an automatic nonreturn valve to prevent the escape of steam in either direction in case of a rupture in the boiler or piping. The connections from the boilers should be made into the top of the header and long-turn bends or sweep elbows used in preference to standard tees or short elbows. The connections to engines should be taken off the top of the header so that any water in the steam will be left behind in the header to be taken care of by the drainage system.

The location of the header depends on local or space conditions, but it is customary to place it above, or else back of the boilers where headroom is available. The practice of running the header along the front of the boilers is not to be recommended because of the danger to the men in case of a break or leak, because space at the front of the boilers is usually at a premium (especially where coal-handling machinery is installed), and because of the exposure to dust and grit occasioned by the handling of coal and ashes. Where the engine room adjoins the boiler room, it is a good plan to place the header inside the engine room, above the engine level, supported by brackets on the wall. It is not good practice to put steam headers in trenches or pits because of inaccessibility.

### Ample Drains Should Be Provided

The drainage of the steam header is one of the most important considerations. All connections to and from the boilers and engines should enter the header at the top to insure that any water that may collect in the header will not be picked up and carried to the engine. To carry away this water the header should be fitted with one or more drains of ample size, connected to good high-pressure traps to avoid the loss of steam. It is not good practice to pitch the header in order to facilitate drainage from one point, since this might result in a large volume of water collecting at some low point and being carried over in a slug with the steam. Instead, where the header is of considerable length the drain connection should be tapped at each end and at the middle if necessary. Each drain should be independent of any other and should be fitted with its own trap and bypass. For steam-header drainage a drain pipe not less than 1 in. should be used. Some engineers prefer to take off a drain connection at each point where the steam is drawn off from the header, since it is reasoned that the draft and flow of the steam in forcing its way to the point of outlet carries the water and moisture along with it to that point. Where boilers are liable to foam or prime or where large quantities of water may find their way into the header, the mere tapping of a drain connection into the header does not afford sufficient capacity for drawing off large slugs and water, and in these cases it will be found advisable to set a drip pocket into the header at the drainage point or points so that any entrained water will fall by gravity out of the flow of the steam and be taken away by the trap. The water from the header, being pure and hot, should be returned to the feed tank or feed-water heater so that both water and heat will be returned to the boiler.

The construction of a steam header should be of the best quality extra-strong pipe, and extra-heavy flanged through-bolt fittings should be used throughout to simplify erection and changes, as well as to facilitate taking up leaks that may develop. For steam pressures up to 150 lb. and no superheat, steel pipe with cast-iron fittings should give satisfaction. Where super-

heated steam or any steam pressure over 150 lb. is encountered, cast-steel fittings should be used throughout. Metallic gaskets or special high-pressure packing material should be used on all joints, for no expense should be spared in securing tight joints in the main steam lines. The improved methods of welding and the elimination of the uncertainty as to the strength and reliability of welded joints has resulted in the adoption of welded headers by many engineers because of the fact that no packing joints need be bothered with. Especially where many special connections at different angles and positions are to be taken off, the welded header is advantageous.

### Allowing for Contraction and Expansion

Expansion and contraction of the header and of the inlet and outlet connections makes it essential that the header be left free to move in any direction, and it is usually best to support the header by chains or on brackets fitted with rollers and expansion springs so that it is free to move in any direction made necessary by the strains imposed upon it. Otherwise, if firmly anchored, the expansion strain is certain to cause leakage, and even rupture might result from the constant strain imposed upon the metal. Some idea of the magnitude of the expansion to be taken care of can be obtained from the following: Saturated steam at 150 lb. absolute has a temperature of 366 deg. in round numbers, and where a superheat of 100 deg. is carried, the steam pipe would be subjected to a temperature of 466 deg. F. Applying the factor or coefficient of expansion of steel pipe, a temperature change of 466 deg. from zero causes an elongation of $\frac{3}{8}$ in. in each 10 ft. of pipe, and where a header is 75 or 100 ft. long this item must be provided for; and since expansion and contraction cannot be prevented, its effects should be guarded against by arranging the pipe in such a manner that its deflection takes up the expansion. If this cannot be done within the piping itself by means of loops and bends, a special expansion joint should be used.

### How to Overcome Vibration Troubles

Vibration of a header or other pipe line is usually due to one of two causes—mechanical vibration communicated from the engines, or vibration produced by pulsations in the flow of steam. The former can be overcome only at the original source of trouble, the engine. The latter indicates faulty design and construction of the steam lines or irregular operation of the engine. Where it is found that the pipe line is really too small for the work, the vibration can frequently be allayed by the use of receivers in the pipe line, preferably near the engine.

Covering is an important item since a header offers considerable area for the radiation of heat, involving not only a loss of heat, but excessive condensation resulting in trouble from moisture. Consequently all headers and in fact all the steam lines should be well covered with insulating material to prevent heat loss. Experiments have shown that each square foot of bare pipe surface will radiate about 3 B.t.u. per hour for each degree difference between the temperature of the steam and that of the surrounding air.

# Power Factor from the Station Operator's Point of View

By L. W. Wyss

A GOOD share of the load delivered by large alternating-current systems is to customers whose loads consist of induction motors and other inductive apparatus. Such loads take a component of current which lags behind the line voltage, and this lowers the power factor of the system. When the current lags behind the voltage it reaches its greatest strength after the voltage has passed its maximum value; and when the current leads the voltage, it reaches its greatest strength before the voltage has reached its maximum value.

This "phase difference" of the current and voltage is measured in degrees and can be represented by the relation between two sine curves showing the voltage and current values respectively. For a given angle the power component of the current is a given fraction of the actual current. This fraction is equal to the cosine of the angle of lag or lead and is called the power factor. This is usually expressed in percentage and is therefore obtained by multiplying the cosine by 100.

It is not easy to measure the degrees of lead or lag, and consequently another method of determining the power factor is used. In actual practice it is calculated by dividing the true power or watts, as measured by a wattmeter, by the apparent power, or volt-amperes obtained by multiplying the volts by the amperes. If the wattmeter reads in kilowatts, the volt-amperes must be divided by 1000 to convert them into kilovolt-amperes before dividing them into the kilowatts. For a three-phase system the volt-amperes and kilovolt-amperes of one phase must be multiplied by $\sqrt{3} = 1.73$ to obtain the total value.

Lagging power factor on the system has the following unfavorable effects on generator: Decreased capacity, decreased efficiency, necessity for increased exciter current, and poor voltage regulation. For instance, assume a 3000-kv.-a. generator to be delivering 2250 kw. at 75 per cent. power factor, which would represent 3000 kv.-a.; namely, its full-load capacity. Now, 3000 kv.-a. at 75 per cent. power factor represents exactly the same actual power as 2250 kv.-a. at 100 per cent. power factor, but it decreases the efficiency of the generator. This is due to larger current at the lower power factor and to the over-excitation of the field required to counteract the flux set up by the armature in opposition to the field, due to its lagging current.

These undesirable effects were found to produce the following results on a certain three-phase hydro-electric unit. For a given turbine gate opening or horsepower delivered to generator,

| Power Factor | Kw. | Kv.-A. | Volts | Amperes |
|---|---|---|---|---|
| 100 per cent. | 2800 | 2800 | 7200 | 225 |
| 59 per cent. | 2650 | 4500 | 7200 | 362 |

That is, it required as much power to drive the generator when it was furnishing only 2650 kw. as it did when it was furnishing 2800 kw., because the power factor was low in the former case.

When several alternators are operated in parallel, the power factor of any one is no indication of the power factor of the system, since the power factor of each unit can be controlled by its field current. It might, for

instance, be acting as a synchronous condenser, carrying more than its share of amperes and kilovolt-amperes. Such would be the case if it were more greatly excited than the others, the power factor of the system then being greater than that of the generator.

Synchronous generators (or motors) can therefore be made to deliver leading current provided they are not loaded to their full kilovolt-ampere capacity at unity power factor. This also applies to rotary converters unless the direct-current voltage regulation is impaired. In the same manner that an increase of field current causes lead, so decrease of current causes lag. The following figures give approximately the performance of a three-phase synchronous machine operating either as a generator or as a motor. They indicate the importance of power-factor regulation of rotary converters and motor-generators at the substations of a system, since for a given kilovolt-ampere capacity they can be made to operate so as to deliver a component of current which leads the line voltage. This is of additional importance when consideration is given to the fact that these substations are usually nearer the inductive load of the system than the generators and therefore a leading power factor at them reduces wattless current transmitted.

| Power Factor | Angle of Lag or Lead | Cosine of Angle | Volts | Amperes | Kw. | Kv.-A |
|---|---|---|---|---|---|---|
| 100 per cent.. | 0 | 1.0 | 7200 | 200 | 2500 | 2500 |
| 67 per cent..... | 48 | 0.67 | 7200 | 300 | 2500 | 3740 |
| 1.75 per cent.. | 89 | 0.0175 | 7200 | 300 | 65 | 3740 |
| 0 per cent..... | 90 | 0 | 7200 | 300 | 0 | 3740 |

The following figures show to what extent a 1000-kv.-a. three-phase synchronous motor could help to raise the power factor of the system to which it is connected if the delivered load were 700 kw.

| Power Factor | Kw. | Kv.-A. | Volts | Amperes | Wattless Component of Kv.-A. | Wattless Component of Amperes |
|---|---|---|---|---|---|---|
| 100 per cent..... | 700 | 700 | 7200 | 56 | | |
| Leading 70 per cent.... | 700 | 1000 | 7200 | 80 | 300 | 24 |

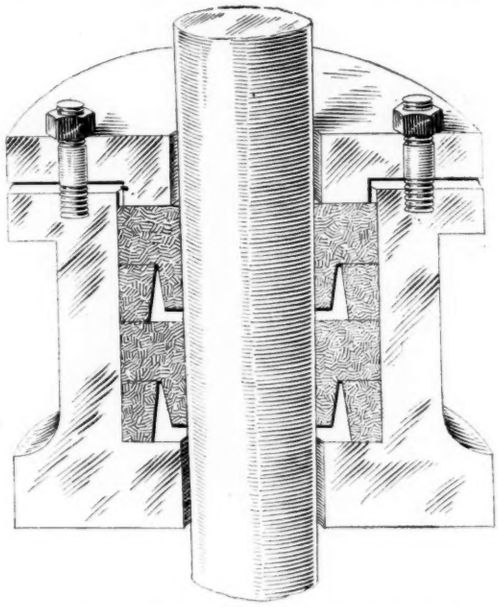
## Triangle Flap-Ring Packing

One of the difficulties engineers experience in connection with the operation of reciprocating engines, pumps, etc., is due to scored, tapered or out-of-line piston rods or plungers. Although new packing may be inserted in the stuffing-boxes, it soon begins to leak when any one of these causes is present.

A packing ring that has been designed to obviate this trouble is known as the Triangle flap-ring packing, made by the Triangle Packing and Rubber Co., 25 Hubbard Place, Brooklyn, N. Y. The illustration shows the construction, each complete ring consisting of two members, one being made with the inside surface beveled, the other with a flap. With this construction the packing will automatically adjust itself, as the flap, being smaller in diameter than the piston rod or plunger, exerts a certain amount of pressure on the rod, and at the same time, being pliable, it will not bind or cause undue friction, but will readily follow any irregularities of the rod or plunger.

For instance, in elevator work when the hydraulically operated car is traveling upward it is necessary that there be no leakage of water, and at the same time there must be no undue friction to slacken the speed of the car. As the car descends by its own weight, the less friction to retard its speed the more satisfactory its operation. An examination of the illustration will show that as the water pressure forces the flap against the plunger when the car is traveling upward, it is made practically tight.

One of the advantages claimed for this packing is that it is not necessary to screw up the glands of the



TRIANGLE FLAP-RING ROD PACKING

stuffing-box to prevent leakage. In packing the stuffing-box, the groove enters the box first so that the pressure strikes the flap and adjusts it to the rod or plunger. Alternate rings enter the same way. The packing is made of materials for every condition of operation.

## A 525-Foot Brick Chimney

Building a chimney 525 ft. high at the Washoe Reduction Works of the Anaconda Mining Co., at Anaconda, Mont., was necessary in order to save the gold, silver, copper and arsenic which under the present

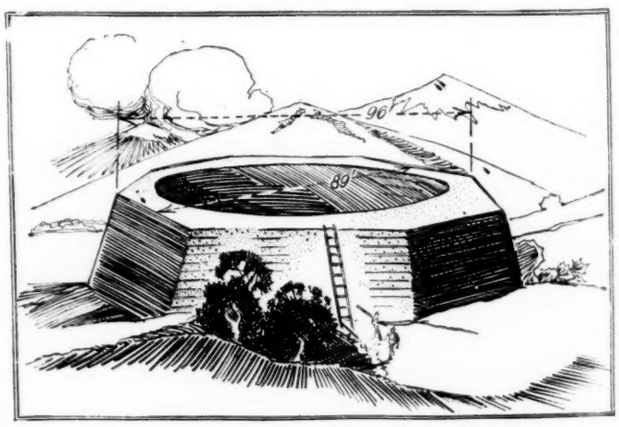



FIG. 1. BASE OF 525-FOOT BRICK CHIMNEY

method are lost in fumes from the converters, reverberatories and roasters. About 32 tons of arsenic will be saved each day.

The base of the chimney, shown in Fig. 1, contains 5000 cu.yd. of concrete and weighs 10,100 tons. The outside measurement of the octagon is 96 ft. from angle to angle, and the sides are 89 ft. from center to center.

The stack will contain 2,300,000 special bricks, equal to 7,000,000 common bricks, and it will weigh when finished 23,600 tons, making the total weight of the base and stack 33,700 tons. The bricks are made at the plant near the works, all the material being obtained from the tailings. Already a large number have been made. Some idea of the work involved may be conceived by the fact that approximately 467 carloads of bricks will be used and have to be transported from the flat to the top of the hill, and the sand, cement and other materials will greatly increase the number of carloads required. Fig. 3 shows the chimney partly completed for a distance of 440 ft. above the foundation.

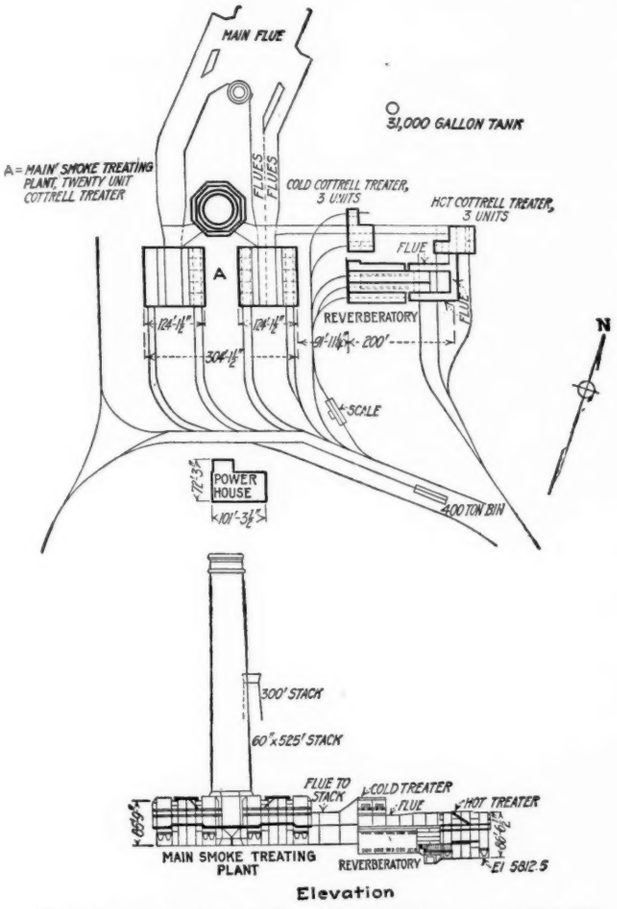



FIG. 2. PLAN OF FLUE CONNECTIONS TO CHIMNEY

The elevation at the top of the base is 5875 ft. above sea level, making the top of the stack 6400 ft. above sea level. There will be two openings where the flues enter, each 16 ft. wide and 60 ft. high. The chimney will be octagonal for 68 ft. from the base and round the rest of the way. It will handle 3,000,000 cu.ft. of gas and 1,000,000 cu.ft. of cooling air per minute at a velocity of 24 ft. per sec. The concrete foundation was poured last fall in the remarkably short time of 22 shifts. As a comparison, the foundation of the stack at Tacoma, Wash., containing 5000 cu.yd., was done in 45 shifts, and the stack at Saganosoki, Japan, containing 2711 cu.yd., required 90 shifts.

The cost of the new stack, together with the smoke and gas-treating plants, will approximate $2,000,000. It will require over a year to complete the construction.

The table, reproduced through the courtesy of W. C. Tapron, chemical superintendent at the Washoe Works, gives data of other large stacks in the world:

| Location: Material..... | New Stack, Anaconda Brick | Old Stack, Mont. Brick | Great Falls, Mont. Brick | Tacoma, Wash. Brick | Saganosoki Japan Reinforced Concrete |
|---|---|---|---|---|---|
| Inside diameter at top..... | 60ft. | 30 ft. | 50 ft. | 23 ft. 11 in. | 26 ft. 3 in. |
| Inside diameter at bottom.... | 76 ft. | 31 ft. | ..... | 39 ft. | 37 ft. 9 in. |
| Thickness of wall at bottom.... | 5 ft. | 5 ft. 2 in. | 5½ ft. | 5 ft. 1 in. | 2 ft. 5½ in. |
| Thickness of wall at top..... | 18 in. | 12½ in. | 18 in. | 13½ in. | 7 in. |
| Height of stack above foundation..... | 525 ft. | 300 ft. | 506 ft. | 571 ft. | 570 ft. |

Extending north from the old stack will be two flues (Fig. 2) each 20 x 50 ft. inside and one flue to the west and one to the east of the old stack. These flues will connect the 20 Cottrell smoke treaters of the Anaconda box type, five on each of four sides.

The material for the main flue will require approximately 900 tons of steel and 7500 tons of hollow tile brick. This is equal to 2,500,000 common bricks. The flue will pass 280 tons of solid matter every 24 hours, traveling at the rate of 60 ft. per second.

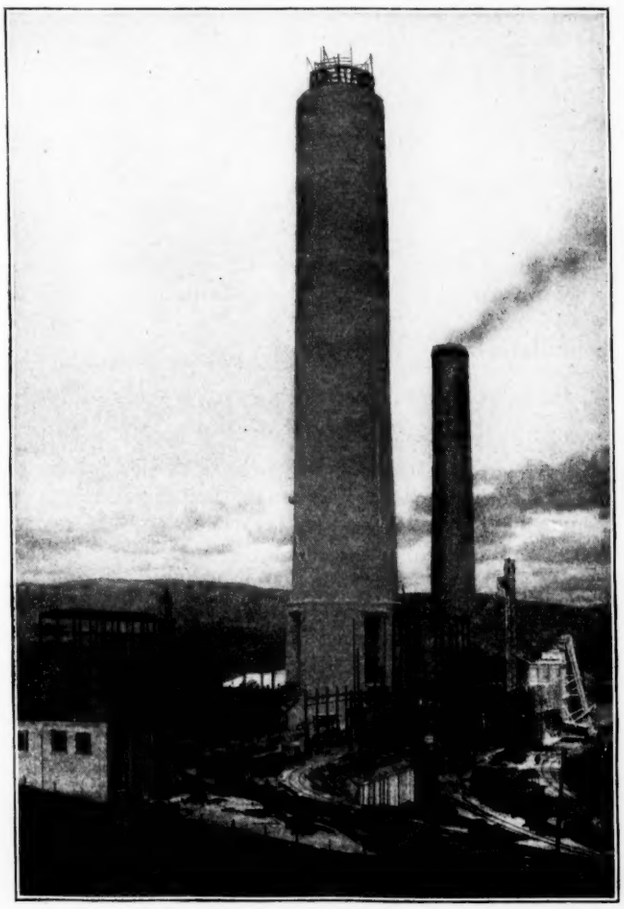


FIG. 3. NEW STACK SHOWING 440 FT. ABOVE THE FOUNDATION

The power house of concrete, brick and steel, will be fireproof and will be 50 x 100 ft. with a shop 21 x 43 ft. The building will contain a rectifier connected directly to the generator shaft to change the alternating energy to direct current and will also have a switchboard equipment, transformers, and other apparatus to make up an up-to-date plant.

# Making a Neglected Refrigerating Plant Give Capacity

By E. W. MILLER

*An unusually interesting and valuable account of what was done to make a comparatively new refrigerating plant give rated capacity. The oil traps never had been blown, the condenser never purged nor frost scraped or melted from the coils. When the troubleman finished with the plant, one machine did the work that formerly required three; the head pressure was 125 lb. instead of 225 pounds.*

AFTER two years' service the owners of a cold-storage plant began to experience trouble in maintaining the proper temperatures when the hot season came on. This was something of a jolt because the manufacturers who installed the plant had assured them that its capacity was easily double the requirements at the time of installation. A few more rooms had been added, but not anything like double the original amount. As they had under consideration, at this time, plans for a considerable addition to the plant, it became a question of whether it would pay to install machine capacity for the new addition or cancel the whole project. The writer was finally called in for consultation.

### Insufficient Piping the Cause of Part of the Trouble

A nephew of the largest stockholder in the concern was in charge of the plant. He had graduated from running his father's farm traction engine to this job, mainly because he could be had cheaper than a properly qualified engineer, and secondly, the owners had been told by the manufacturers that it was a simple matter to handle a refrigerating plant. In addition they hired a clerk who had previously worked in another plant which the manager and himself had run between them with the aid of the fireman and a night watchman.

The plant was excellently insulated. The piping, however, was insufficient in a number of the rooms and especially in those that had been added after the first part of the system had been completed. This would account for part of the troubles.

After checking over the plant and estimating the work required for each individual room, the owners were rather stunned by my statement that one machine should easily carry the entire load and still have capacity to spare. At this time they kept two machines "dancing" and even then were unable to keep the temperature down. I was told to thoroughly investigate the plant and make recommendations as to what should be done.

As stated, there was insufficient piping in most of the rooms. That was only one item. Part of the coolers were cooled by a fan system in which the air was circulated through a bunker room and through ducts to the coolers. The frost on these bunker coils had apparently never been removed since the plant was started. It was over a foot thick in places. Nearly all the direct expansion coils in the rest of the rooms were in the same condition. This in connection with the shortage of pipe meant that the suction pressure would have to be kept low enough to keep up a sufficiently high rate of heat transfer through the mass of frost and small pipe surface. This in itself was probably enough to reduce the capacity of the machines by about half.

This was not all, however. The young engineer prided himself on the way he kept the compressor lubricated. He used only the best of oil and used it in liberal quantities according to his own statements, which I readily verified. In his own words, "Oil costs less than new machinery." This may hold good in some places, but not in a refrigerating plant.

When asked regarding blowing out the oil trap, he confessed ignorance regarding the traps. These had never been blown out to his knowledge since the plant had been started. Evidently the system was loaded with oil which still further reduced the heat transfer through the expansion coils and of course meant a still lower suction pressure to maintain the proper temperatures.

The condenser pressure was about 225 lb. The cooling water was taken from a well at a temperature of 56 deg. and the condenser pressure should have been down to about 150 lb., and even lower, as the condenser was of ample capacity when the two machines were operated at maximum capacity.

### The Condenser Had Never Been Purged

Inquiry brought out the fact that the condenser had never been purged. They had never made any attempt to pump out the air when additional coils had been put in on new work or after the old ones had been opened for repairs. Furthermore, when they opened any part of the system for repairs, it had been the usual practice to arrange a bag over the place where they desired to break the joints and then run water over it from a hose to dispose of the ammonia as it escaped.

There was no gage-glass on the receiver, and it was impossible to judge in this manner the amount of ammonia in the system. After putting a gage-glass on the receiver, I found there was not a sign of liquid in the glass. I was then informed that there surely must be plenty in the system because they had added two 100 lb. drums nearly every month and surely this ought to be sufficient for a plant doing approximately 35 tons work. He was informed that this should have been plenty to run them for a year at least in a plant of this capacity.

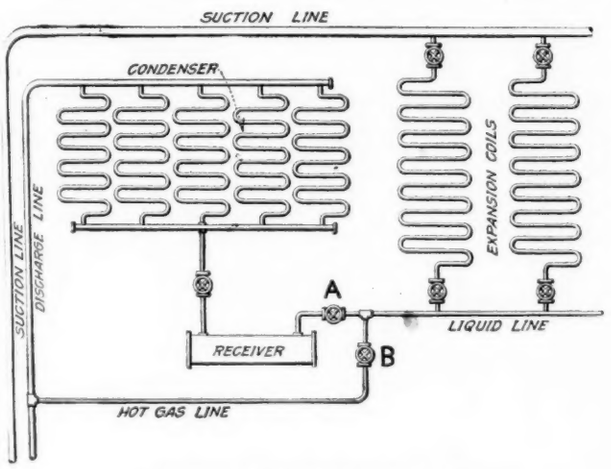
My first move was to purge the condenser, which was of the atmospheric type. After I had spent about two hours at this, the engineer became alarmed because the condenser pressure had dropped to 130 lb. He eyed

me suspiciously when I told him that the pressure should never run more than ten pounds higher than this with the temperature of condenser water available.

The oil traps were full, and there were three of them, two in the discharge lines and one on the suction. I drew off a bucketful from each and later on in the day got half a bucketful from the three of them.

The machines were of the horizontal double-acting type with the valves in the heads. I shut one of them down and treated the engineer to some unusual "stunts" when I pumped it out by means of the bypasses. A complete set of valves were provided for each machine. Performing the same operation on the other machine, I found that one valve in this machine was in bad shape, and this was replaced with a new one.

There was no doubt about where a large part of the 200 lb. of ammonia per month had gone. The stuffing-boxes on both machines leaked continuously; there was quite a shoulder on each rod. In adjusting the crosshead shoes the wear had been all taken up on the bottom, while the wear, as a rule, on this type of machine is on the top. As a consequence the crosshead end of the rod was about ⅛-in. higher than the center line of the




SHOWING THE PIPING LAYOUT

compressor and there was this much up-and-down motion of the rod at each stroke. The best-managed stuffing-box could not hold tight under these conditions.

Arrangements were made with a nearby machine shop to turn down the rods. The next day was Saturday, a light day, so we shut down one of the machines, pulled the rod out and sent it to the shop. In taking out the rod I found the piston rings so loose that they were practically useless; new rings were ordered. The rod was back ready to run Sunday noon. A junk ring was placed in the bottom of the stuffing-box to compensate for the decreased diameter of the rod, and the crosshead shoes were properly adjusted. When the machine was started, it dropped the suction pressure down to the same point that the two machines had held it before, indicating that this machine was doing the same work that the two had been doing. The other machines were given similar treatment.

A few hook-shaped scrapers were made in a near-by blacksmith shop and laborers set to work removing the frost from the coils. In addition 5000 ft. of 2-in. pipe was added to that already in the coolers to provide a liberal coil surface for the work to be done.

Cleaning the coils jumped the suction pressure from 3 to 15 lb., and by keeping one machine going fast it was now possible to carry the load most of the time with one machine. A cross-connection from the discharge line to the liquid line from the receiver to the expansion coils, as shown in the sketch, was made. By this means it was possible to deliver hot gas direct from the discharge line into any one of the expansion coils and remove every vestige of frost from them. This method of cleaning the coils loosened the oil adhering to the walls of the coils and started it in circulation carrying it to the coil traps where it could be blown off. To clean any one coil it was only necessary to shut off the valve *A* in the liquid line at the receiver and all the expansion valves on all the coils but the one to be cleaned. On this coil the expansion valve was opened wide and the suction valve was shut. Valve *B* in the cross-connection from the discharge line was then opened and the hot gas put into the coil, the coil acting as a condenser. After the coil is cleaned, the expansion valve is shut off and the suction valve carefully opened until a slight hissing sound is heard. If the suction valve is opened too far at first, there is danger of carrying slugs of liquid back to the compressor. It is best to take about an hour or so in pumping out a coil after cleaning in this manner the first time. After a little practice it can be done in ten to fifteen minutes.

While this coil is being pumped, the valve *B* is shut, valve *A* is opened and the expansion valves reset on the rest of the coils. When the cleaned coil is pumped out, as indicated by frost beginning to form on the coil, the suction valve is opened wide and the expansion valve set when conditions are back to normal.

### One Machine Carries the Load

Cleaning the coils sent the suction pressure up another 2 lb. We could now carry the load easily with one machine at considerably reduced speed a large part of the time. The coal consumption had been reduced approximately 25 per cent, and this was quite unexpected, considering that there was considerable other equipment supplied by the same boilers. Every joint in the place was then gone over with a sulphur stick to test it for leaks. After covering the whole plant, the large ammonia loss did not surprise me. Some of the pipe lines and connections on the condenser were veritable sieves. Two of the joints in the condenser were under water and leaking badly, but would never have been noticed unless one was carefully looking for them.

For a number of joints it was necessary only to tighten the bolts. In others we renewed the gaskets. After the new joints had been taken up a few times, it was impossible to find a leak around the plant. I had added 400 lb. of ammonia shortly after I came on the job, and this sufficed for a year. This brought the charge in the system up to a point where the receiver was nearly full when in normal operation; this had much to do with the increase of capacity of the compressors.

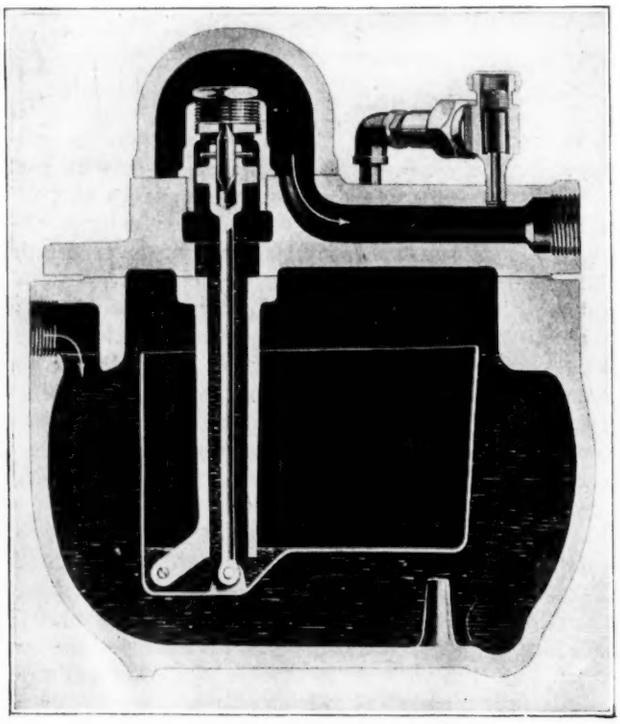
When the additional 5000 ft. of piping had been installed in the coolers, the suction pressure came up to 22 lb. and at times even higher. A large part of the time one machine only was running at about two-thirds normal speed and the fireman was congratulating himself on the soft snap he was having.

Purging the condenser a few more times had thoroughly eliminated the air from the system and the condenser pressure varied between 120 and 125 lb. No more oil was used in the compressors because there was more than enough circulating in the system to keep it going for many a day. The only oil used was a slight amount fed through an oil cup into the front gland of the stuffing-box. After the new hot gas line was installed for cleaning the coils, we got a pailful of oil on some days for the first week, but this gradually decreased until, after the plant had been in operation a month, we got a pailful every week from the traps. Later in the summer it dwindled down to less than a gallon a week. During the next winter season the expansion and condenser coils of the system were thoroughly blown out with steam and the ammonia sent to the manufacturers and purified. This put the plant in the pink of condition. To the young engineer's credit it must be said that it has been kept that way ever since.

## Swartwout Hydromatic Vacuum Trap

The Swartwout hydromatic trap, described on page 403 of the Sept. 10, 1912, issue of *Power*, has been improved by the Ohio Blower Co., Cleveland, Ohio, so that by the addition of a vacuum attachment it can be used as as vacuum trap.

This attachment consists of a small expansion valve (see accompanying illustration) so constructed that when the trap becomes cool because of air that has collected in the upper part, the valve automatically opens and releases the air, which is pulled out by the vacuum pump. When steam reaches the valve in the vacuum attachment, it is automatically closed again, thus preventing loss of steam.



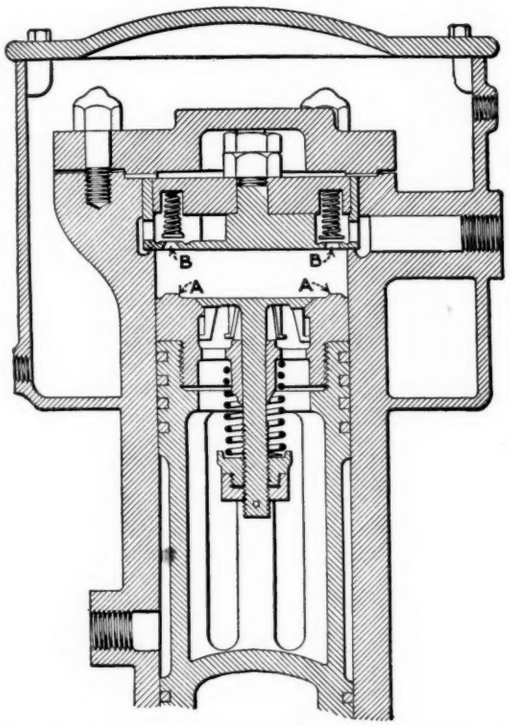
SECTION THROUGH VACUUM TRAP

The illustration shows the trap just before discharging. Further rise of the water fills the bucket and causes the right side to drop until it strikes the post below. The lever action of the bucket on its hinge acts on the pull rod of the discharge valve and opens the valve. Steam pressure then empties the bucket and the buoyancy lifts it and closes the valve.

It will be seen that no steam can pass over through the discharge on account of the water seal within the bucket.

## Niebling High-Speed Compressor

The aim of designers in the construction of air compressors and refrigerating machines has been to reduce the clearance as much as possible. A number of ideas have been brought out with this object in view, among them that by the Niebling-Markstein Co., 201 Bell Block, Cincinnati, Ohio, shown in the illustration. The device consists of a projecting ring *A* on the outer end of the piston, which fits into a groove of the same width and diameter and in which the valve pockets *B* are arranged. It is used with air, ammonia or any other gases. It will be seen that the valves are of the plate type and the construction of the valve head and the piston is such that practically all clearance is eliminated. The machines are built with one, two, three and four, and, in some cases, as high as six cylinders. They are adapted for high-speed oil and gas-engine drive and are direct-connected.




SECTION THROUGH CYLINDER OF HIGH-SPEED COMPRESSOR

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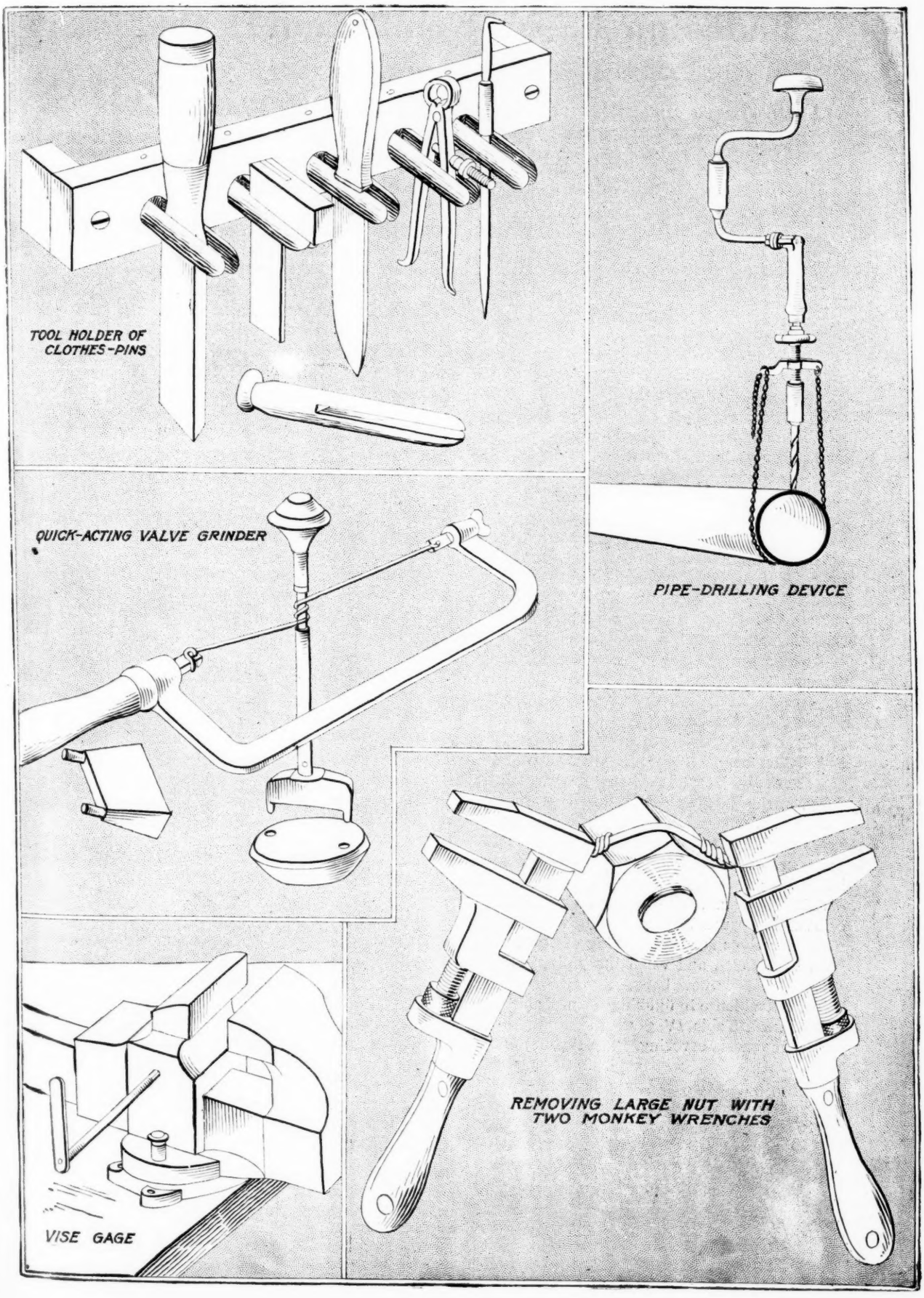
It is stated that during the recent French offensive the consumption of gasoline for the army and air service was at the rate of eighteen hundred tons, or approximately five hundred thousand gallons, a day. Automobile owners can thus see where a portion of the gasoline that was saved during the gasless Sundays did the most good.

# Handy Kinks Worth Knowing



# Radiation Losses from Steam-Heated Surfaces

**Following is the fifth weekly letter sent out by the Administrative Engineer for Illinois. Data on the saving that may be effected are given and all owners and operators are urged to look into the possibilities in their respective plants**

By steam-heated surfaces we mean drums or shells of boilers and steam piping; also boiler-feed lines, hot-water returns and the like.

This is one of the most easily accounted for losses in the power plant and it is one for which no excuse can be given. The cost of covering steam pipe is so quickly made up by the saving which results therefrom that uncovered piping or parts of the boiler should not be tolerated for a single day.

To give an idea of what it means to have uncovered steam and hot-water piping the accompanying tables are presented. All that is necessary to find out how much coal is being wasted is to determine the steam pressure or hot-water temperature, measure the amount of uncovered surface and multiply the square feet of uncovered surface by the figure in column 5 of Table II or column 4 of Table III, that corresponds to the steam pressure. For example, when the steam gage shows 100 lb. pressure, there is a waste of 718 lb. of coal per year for every square foot of exposed pipe.

There are a number of excellent materials readily obtainable for covering steam piping and boiler drums. The Administrative Engineer asks that each interested party, without delay, make a detailed examination of the piping, list the various sizes and lengths of exposed pipe, and place the order at once for the necessary covering. He also asks that a letter be written to him with a copy to the district chairman, within one week of the receipt of the present letter, stating whether the necessary steps for the covering of the piping have been taken and when the piping will be covered, if it is now bare.

For convenience in figuring the probable cost of the work Table IV gives the approximate cost of magnesia covering. The expense is the initial cost only, because pipe covering will remain in place indefinitely, unless it is deliberately destroyed. Here is the means of a direct and inexpensive economy which should not be overlooked.

A square foot of ordinary bare pipe will radiate approximately 3 B.t.u. per square foot per hour per degree difference between the temperature of the steam and the outside, or room, temperature. A properly covered pipe, however, radiates only about 0.3 B.t.u. per square foot per hour per degree difference of temperature. Table I gives the lengths of pipe of various sizes per square foot of outside surface. Tables II and III give the annual waste of coal and Table IV the cost of magnesia pipe covering.

TABLE I. LENGTH OF PIPE PER SQUARE FOOT OF SURFACE

| Pipe Diam., In. | Feet of Pipe per Sq.Ft. of Ext. Surface | Inches of Pipe per Sq.Ft. of Ext. Surface |
|---|---|---|
| 1 | 2.9 | 34 4/11 |
| 2 | 1.6 | 19 2/11 |
| 3 | 1.0 | 12 |
| 4 | 0.84 | 10 1/11 |
| 5 | 0.68 | 8 2/11 |
| 6 | 0.57 | 6 9/11 |
| 8 | 0.44 | 5 2/11 |
| 10 | 0.35 | 4 2/11 |

TABLE II. COAL WASTE FROM UNCOVERED STEAM PIPE

(Temperature of surrounding air 70 deg. F.)

| 1 Steam Pressure, Gage | 2 Steam Temp., Deg. F. | 3 Difference Between Temp. of Steam and Sur. Air, Deg. F. | 4 Heat Loss per Sq.Ft. per Hr. per Deg. Dif. B.t.u. | 5 Waste of Coal Lb. per Sq.Ft., per Year. | 6 Sq.Ft. of Surface That Wastes a Ton of Coal in 1 Year. |
|---|---|---|---|---|---|
| 0 | 212 | 142 | 334 | 293 | 6.82 |
| 10 | 240 | 170 | 425 | 372 | 5.38 |
| 25 | 267 | 197 | 522.5 | 458 | 4.37 |
| 50 | 298 | 228 | 644 | 564 | 3.55 |
| 75 | 320 | 250 | 737.5 | 646 | 3.10 |
| 100 | 338 | 268 | 820 | 718 | 2.79 |
| 150 | 366 | 296 | 960 | 840 | 2.38 |
| 200 | 388 | 318 | 1,079 | 945 | 2.12 |
| 250 | 406 | 336 | 1,184 | 1,036 | 1.93 |

TABLE III. COAL WASTE FROM UNCOVERED HOT-WATER PIPES

| 1 Water Temp., Deg. F. | 2 Difference Between Water Temp. and Sur. Air, Deg. F. | 3 Heat Loss per Sq.Ft. per Hr. per Deg., Dif., B.t.u. | 4 Waste of Coal, Lb. per Sq.Ft. per Year | 5 Sq.Ft. of Surface That Wastes a Ton of Coal in 1 Year |
|---|---|---|---|---|
| 100 | 30 | 56.6 | 49.6 | 40.3 |
| 120 | 50 | 97.5 | 85.4 | 23.4 |
| 140 | 70 | 142 | 124.3 | 16.1 |
| 160 | 90 | 190 | 166.3 | 12.03 |
| 180 | 110 | 242 | 212.0 | 9.44 |
| 200 | 130 | 298.5 | 261.5 | 7.65 |

TABLE IV. PRICES OF MAGNESIA PIPE COVERINGS

| Inside Diam. of Pipe, In. | Thickness of Stand. Cov., In. | Price per Lin. Ft., Canvas Jacketed | Thickness of Covering, In. | Price per Lin. Ft., Canvas Jacketed |
|---|---|---|---|---|
| 1 | 1 | $0.27 | 1½ | $0.52 |
| 2 | 1 1/16 | .36 | 1½ | .64 |
| 3 | 1 1/16 | .45 | 1½ | .76 |
| 4 | 1¼ | .60 | 1½ | .88 |
| 5 | 1¼ | .70 | 1½ | 1.00 |
| 6 | 1¼ | .80 | 1½ | 1.10 |
| 8 | 1¼ | 1.10 | 1½ | 1.35 |
| 10 | 1¼ | 1.30 | 1½ | 1.65 |

# EDITORIALS

## Shall the Work of the United States Fuel Administration Be Continued?

THE maintenance and conservation of the fuel supply is imperative in times of war. Is it not desirable in times of peace?

In a century and a half we have developed a system of industry, transportation and domestic service made possible by the production of power by fuel. One has only to observe how many of the necessities, comforts and services of his daily life are dependent upon fuel to realize the vast import of its growing scarcity. The manufacture and transportation of almost everything his house contains, of the very materials of which that house is built, of the clothes he wears, of the food he eats, the warming of his home, the cooking of his meals, the light which he burns, his water supply, his own transportation to his shop or office, the comfort and facilities of his occupational surroundings, often the power which operates the apparatus or the heat necessary to the processes which he controls require in the great majority of cases the burning of fuel. In what, unless it is their food supply, have the people collectively a greater interest? In what has the individual a smaller chance for control? What is a more logical subject for collective or governmental organization and supervision?

The saying, "That government is best which governs least," is true of the restraining and compelling activities of a ruler, restraint of personal liberty in directions not essential to the common good, compulsion to render service and pay taxes for the benefit or aggrandization of a class. But a government, in our case the people collectively, can do things for the general welfare that cannot be done so well, if at all, by the individual. No one regards a municipal government as paternal because it devotes an interested and anxious attention to the sufficiency and purity of its water supply, or maintains a fire department and a system of sewers. The days of wells and fire buckets and cesspools are over. No one accuses the State of paternalism because it has replaced the old system of privately owned toll roads and bridges with a system of highways maintained by the people collectively. Why urge paternalism against the collective—the governmental—control of the production, distribution and use of a commodity so necessary to the comfort and well-being, even to the continued existence of the people, as fuel?

This question was in the air before the war began. The private control of the sources, the production, the distribution and the price of fuel was evident. The fact that a manufacturer in wasting fuel was wasting not his own but his customer's money, and impoverishing not his own but a national resource, was becoming increasingly apparent to a growing number of minds. The war forced upon us a degree of control and efficiency that it might have taken years of agitation and voluntary effort to effect.

And the result has been good. With all the handicaps of an emergency service hastily effected, hampered by the confusion and the exigencies of war, it has been demonstrated that immense savings can be made without entailing hardship upon anybody, and that, given the necessary means and power, a government department can compel the production and distribution of fuel at a price that will pay the producer a fair profit. No producer should contend for more and no purchaser should expect to pay less.

The activities of the United States Fuel Administration should be continued. Its experience has demonstrated that the proper execution of the measures that it has in operation and contemplation will result in the saving of fifty to one hundred million tons of coal a year, the value of which would equal one quarter of the interest upon the vastly increased national debt. The public, at the expense of laborious work and the best economic thought, has been taught the idea of conservation and elimination of unnecessary waste. If the effort is now relaxed, the momentum of the movement will be difficult and costly to regain.

The governmental body to logically take over this task is the Department of the Interior. The carrying out of the measures already in hand and projected would be only a natural expansion of the excellent work which the Bureau of Mines has already done and is still doing in the line of fuel conservation. In the Geological Survey, to which the Bureau of Mines pertains, this work would be naturally coördinated with the study and development of the water powers.

Let the lesson of the war not go unheeded. Let all the information and organization and experience, all the plans and projects that have been accumulated and worked out at so much expense by the United States Fuel Administration not be dispersed and sacrificed. Eventually, we shall come to governmental control of the production, distribution and use of fuel. Why not continue and perfect the system that has served us through the war?

## Coal Saving by Scientific Control Of Boiler Plants

MANY of the observations by Mr. Brownlie in his report of tests made on hundreds of boilers in Great Britain, an abstract of which appears on another page in this issue, are applicable to boiler practice in this country. It is unfortunate in some respects that the report in the main is a mathematical average of the results obtained in a large variety of plants, because the average performance of two boilers, one of a small inefficient type and the other of the highest perfection, does not furnish a satisfactory basis for comparison. The grouping in several instances, however, helps considerably. For instance, the table in reference to the $CO_2$ analysis designates the plants, in five groups, as very good, good, medium, poor and very bad, giving the

number of plants falling under each classification. This table tells about as much as can be put into the given space.

It is stated that the average efficiency of the plants tested was only about sixty per cent. which impresses one as being low and the fact that substantial improvements were realized by better management proves it, and also that the average boiler is capable of much better performance. Here again one of the tables gives useful information as to the size of the plants in tons of coal used per year divided into seven groups. Mr. Brownlie's remarks in regard to the purchase of fuel on the basis of its heat value are well to the point. This has often been urged by *Power* as the only businesslike procedure. As a whole the report is well worth careful study.

## Making Diesel Operators From Steam Engineers

OPERATORS of Diesel engines in the United States have been recruited from the ranks of the steam-engineering fraternity to a large extent. In some cases the engineer of a plant was retained when the change from steam to oil engines was made. In other cases the owner hired a steam engineer to run his new Diesel engines because to his mind engines were engines and a man able to run one kind should be just as well able to care for the other kind.

This assumption proved correct in a few instances and the results were satisfactory; but in a good many cases there was trouble, the Diesel engines being blamed for all sorts of defective operation.

Now, there is a great difference between the steam engine and the Diesel engine, both as to the principle of action and the conditions of pressure and temperature. In a steam engine, even with superheated steam, the temperature will not run much over six hundred degrees. In a Diesel engine the temperature in the cylinder may easily reach two thousand five hundred to three thousand degrees. Steam pressures may easily run as high as three hundred and fifty pounds in steam-engine work, but in Diesel engines the compression alone is carried to five hundred pounds.

It is to be suspected, therefore, that some of the trouble with the management of Diesel engines has been due to the attempt of operating engineers to handle these engines in the same way as steam engines, when, in fact they demand more skilled attendance than the average steam engine receives.

With compression pressures approaching forty atmospheres, and explosion pressures considerably higher, it is plain that the fit of the piston in the cylinder must be far more snug than is thought of in steam-engine practice. Where a steam engineer got along satisfactorily with clearances of hundredths of an inch, the Diesel engineer found he had to work to thousandths. Similarly, valves that would be amply tight for steam pressure would be anything but tight under the pressures generated in the Diesel engine.

Someone has expressed the difference between the two classes of engines by saying that a steam engine can be kept going even though it is spitting steam at every joint, but that a Diesel engine either runs efficiently or else it does not run at all. In other words, tightness of valves and piston and correct timing of the valves are necessary in the Diesel engine and any serious leakage or poor timing results in failure to run.

It is not to be expected, therefore, that an engineer trained in the school of steam-engine operation shall be able to apply his knowledge, without modification, to the successful management of Diesel engines. He has a splendid foundation on which to build, but he must learn the peculiarities and the characteristics of this new prime mover and adapt his methods to the altered conditions of operation.

To put it another way, he must either forget or unlearn some of the things that steam engineering taught him to be good practice. The sooner he accepts this idea and sets to work to profit by it, the more rapid will be his progress toward becoming a successful Diesel engineer.

No one but a Diesel zealot, of course, believes that this type of oil engine is going to displace steam power completely. Common sense will show that the present generation of steam engineers need not lie awake of nights, worrying over the abandonment of steam engines for oil engines. But there is a widening field for Diesel engines, and the indications are that those engineers who are far-sighted and ambitious enough to familiarize themselves with successful methods of operating such engines will be in position to reap substantial rewards for their foresight and preparedness.

## More Turbine Accidents

On Wednesday, November 27 the forty-five thousand kilowatt single-cylinder impulse turbine in the plant of the Detroit Edison Company was slightly damaged in its last stage. Contrary to reports that the last wheel had burst, the damage is confined to four blades of this wheel, the blades having broken off a few inches above the rim of the wheel.

The vibration following the loss of the blades and consequent unbalance badly shook the governor, but did not seriously injure it. There were no injuries to the crew. Happily, it looks as though no serious power shortage will follow this minor accident, as the turbine will be put in service after the usual examination. This turbine is one of two of the largest machines of this type, and it has been running with all its wheels in use.

We have just learned of an accident to a fifteen thousand kilowatt impulse turbine in the Market Street Station of the New Orleans Railway and Light Company. The accident occured on September 26 last, failure of the last wheel taking place at a crack extending between two holes—balance holes—in this wheel. The piece in flying out of the wheel, struck the adjacent diaphragm, breaking it. The buckets on five wheels were destroyed. Two holes were broken in the low pressure casing.

This machine was of comparatively old design though recently constructed, it having been installed last May. The load at the time of the accident was twelve thousand kilowatts. The peripheral speed of the last wheel of this machine was approximately seven hundred feet per second. No one was injured.

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A smokeless chimney is not necessarily a proof of efficient combustion. Excess air may be in, or the fire may be out.

# CORRESPONDENCE

**In these and other columns "Power" wants to tell how you have decreased the fuel consumption in your plant. Since the fuel shortage, engineers have been thinking hard about conserving fuel. Thousands have made changes in equipment, in operating methods, and in modifications to boiler settings, etc., all of which have, in many plants, greatly cut fuel consumption. You owe it to the country to tell your fellow-engineers how you have saved coal. "Power" will pay for good articles that will help the other fellow save coal as you have saved it. Engineers must save at least 35 million tons this year. Let's have your story.**

## Reservoir Water-Level Indicator and Recorder

We use compressed air for pumping three wells, discharging into a brick reservoir 94 ft. in diameter. The distance from the reservoir to the engine room is about 300 ft., and when we had to depend on the engineer to watch it, the reservoir ran over about one-third of the time.

To obviate the inconvenience and waste and to have a record of the supply of water, I devised the arrangement shown in the illustration, Fig. 1. A pipe was run from the reservoir on a level to the engine room to the bottom of an 8-in. standpipe about 7 ft. long forming the float chamber. A copper float 6-in. in diameter and 8 in. long was made and put inside and a long rod attached to the top, which operates the indicator and register as shown. The cabinet is about 9 ft. high and holds the apparatus, the recorder and the indicator. From full to empty the pointer travels 3 ft., and this space is marked off in quarters, halves and whole feet. At the top may be seen a receptacle into which is screwed a red lamp, which lights up when the indicator is at 3, indicating a full reservoir. The recording is done by a time recorder connected to the float rod by a cord and reducing motion at the upper right-hand corner. The chart has ten divisions and No. 9 is the maximum, or a full reservoir. A specimen chart is shown.

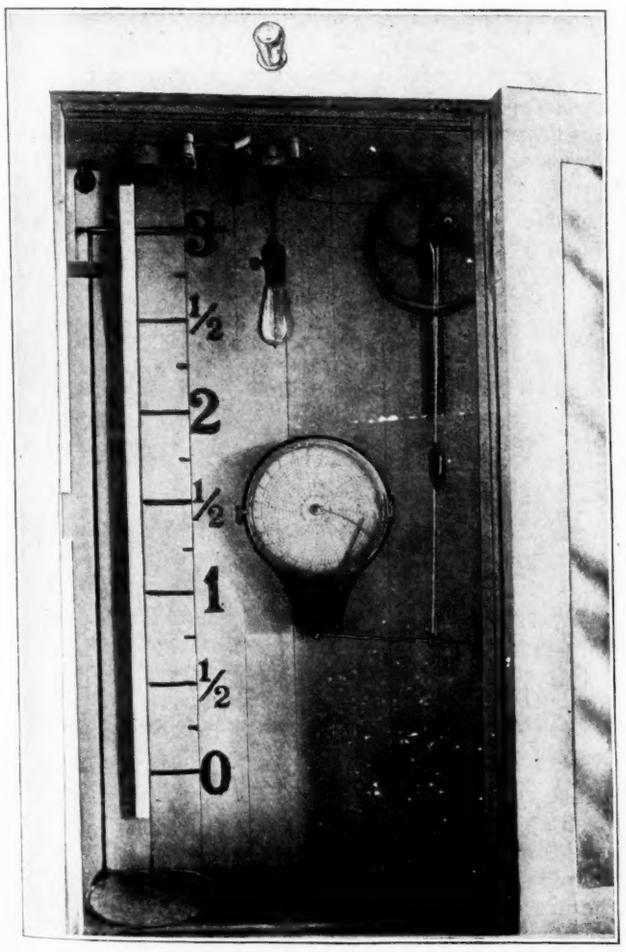



FIG. 1. WATER-LEVEL INDICATOR AND RECORDER IN CABINET

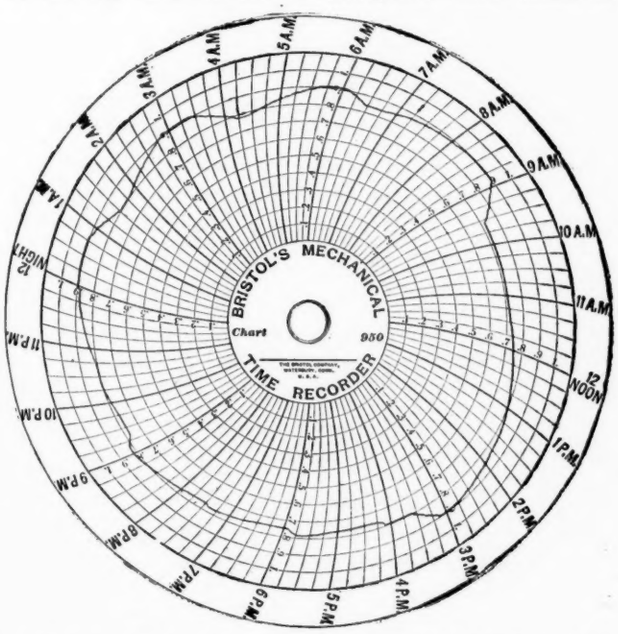



FIG. 2. RECORD OF WATER LEVEL IN RESERVOIR

Canton, Miss J. T. SHARP, JR.

## Discussion of Indicator Diagrams

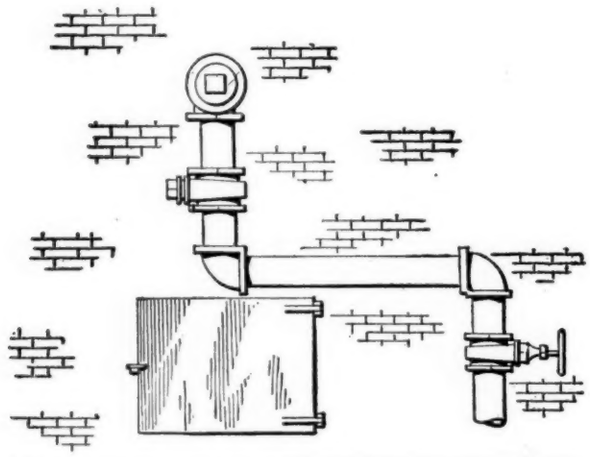
In regard to the indicator diagrams from the steam cylinder of an air compressor contributed by Mr. Shephard in the issue of Nov. 19, page 754, I would suggest operating without compression in the steam cylinders and depending upon the air in the air cylinders for retarding the piston as it comes to the end of the stroke, if the steam and air cylinders are in tandem

I obtained good results from a Corliss cross-compound compressor with steam and air cylinders in tandem in one plant of which I was in charge.

Willsboro, N. Y. C. RICHARD WARD.

## Boiler Blowoff Valves

The illustration shows the blowoff-piping arrangement that I have used for more than 16 years with excellent results. On the end of the pipe that extends from the boiler through the brick wall, a tee is used instead of an elbow and when the boiler is inspected the plug in the outer end of this tee is removed, making



ONE ARRANGEMENT OF BLOWOFF PIPING

it possible to ascertain the exact condition of the pipe, which cannot be done if an elbow is used at this point. Both the asbestos-packed plug cock and the gate valve are located in vertical sections of the pipe, and scale has never lodged in either of them enough to prevent them from closing. They are operated as follows:

The gate valve is first opened wide, then the cock is opened to its full capacity. When the water level is lowered to the proper point, the cock is slowly closed, then the gate valve is closed. One advantage of this plan is that scale and sediment go through the gate valve when it is wide open and is therefore not likely to injure the surfaces that come together when the valve is shut, and anything that can get through the pipe will pass through the valve. Sediment cannot lodge in the bottom of the valve, because it is in a vertical position. As the valves on three boilers are still tight after the long term of service mentioned, it seems to be evidence that the arrangement is good.

I do not know whether the plug cocks are tight or not, but if they do leak a little it does no harm, because they are used only to gradually start the flow of water through the blowoff pipe, then to slowly bring it to a state of rest. If small pieces of scale should be caught in these cocks when nearly closed, they would be sheared off without preventing the cocks from closing or injuring them. W. H. WAKEMAN.

New Haven, Conn.

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I have read with interest the article and discussion letters on the subject of boiler blowoff valves, in the issues of Nov. 12, page 718, and Oct. 15, page 565, and I agree with Mr. Fish and Mr. Lewis in regard to placing a valve between the plug cock and boiler instead of in the reverse order. An experience in the last plant I worked in proved to me the danger of the latter.

I had been there only a short time when one night the fireman complained that the blowoff cock on No. 2 boiler was leaking badly. It was a packed cock held in place by four ½-in. bolts. I had to take the boiler off the line because the cock was between the boiler and the valve. After packing it and renewing the bolts, which were nearly corroded through, I put the plate on, but upon screwing down the nuts the plate broke in two. I shudder to think what would have happened if anyone had tried to tighten the gland with the full boiler pressure (150 lb.) on. If the valve had been next to the boiler, no serious accident would have been likely to happen. D. G. SIMMONS.

Hudson, N. Y.

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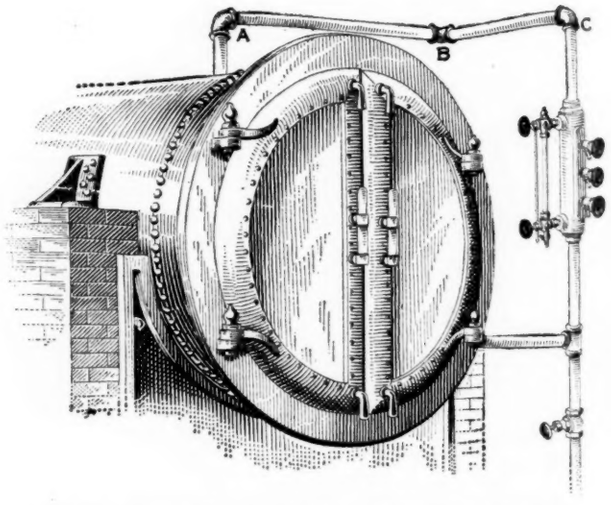
The old and unsatisfactory type of plug cock, fortunately, is not used on the blowoff pipes in up-to-date power plants. Engineers know that a plug cock that depends upon the bottom nut for its seating is not a very safe one to use anywhere, especially on a boiler blowoff pipe.

If a plug cock is used that has the plug held in place by a substantial guard or gland as specified in the A. S. M. E. Boiler Code, there is no occasion to have a "creepy" feeling or of being afraid of being "blown up." Our observation is that in most plants the arrangement is similar to that shown by Mr. Dale; namely, to have the plug cock next to the boiler and the valve beyond.

Pittsburgh, Penn. S. I. FINK.

## Pocket in Steam Connection to Water Column

A new horizontal-tubular boiler had its water column connected as shown in the illustration. The pipe *ABC* dipped about 2 in. at *B*, forming a pocket or trap. When the water was at the level of the lower gage water ap-




WATER SEAL IN STEAM CONNECTION TO WATER COLUMN

peared when either of the upper cocks was tried; steam would appear for an instant and then water. Opening these cocks caused a slight reduction in the pressure in the column and a consequent rise of water in the column. The fire was drawn and the pipe changed to eliminate the pocket at *B*, and the trouble was completely overcome. JAY M. WHITHAM.

Philadelphia, Penn.

## Water-Power Principles

There are several errors in a recent series of articles in *Power* by David R. Shearer. On page 563 of the Oct. 15 issue he writes that a number of velocity measurements are made in a stream and the numerical average of these is the average velocity of the stream. The rate of discharge is then obtained by multiplying this value by the cross-sectional area. This is not true. The correct way is to multiply each observed velocity by the area assumed to be affected by it and the sum of these products is the total rate of discharge of the stream. The true average velocity, if it is then desired, is obtained by dividing the latter quantity by the area.

Actually there is more to the problem than this, as a reference to "River Discharge" by Hoyt and Grover will show. The following numerical example will illustrate the principle that he has violated. Suppose three observed velocities to be 3, 8 and 1, while the areas of which these are the mean velocities are 2, 4 and 9 respectively. The true rate of discharge is then $6 + 32 + 9 = 47$. But, according to Mr. Shearer, he would multiply the mean of the velocities, or 4, by the total area, which is 15, and obtain 60 as the result. The only case in which the mean of the observed velocities is the true average velocity is when the partial areas are all equal.

In Fig. 1 of page 670 of the Nov. 5 issue he shows a picture of a current wheel, but labels it an undershot wheel. As generally understood by hydraulic engineers, a current wheel is one which dips into a free stream, while when the stream is confined so that it cannot escape around or under the blades of the wheel the latter is then an undershot wheel. Quite often the water is dammed up and allowed to escape under a small head so as to strike the undershot wheel with a higher velocity.

On the same page Mr. Shearer states that a disadvantage of the overshot wheel is that it is difficult to govern accurately and efficiently. While this statement might be true in a sense, it is misleading. Close speed regulation may be troublesome for the reasons he has stated, but that is offset to some extent by the inertia of the heavy wheel. So far as efficiency is concerned, the overshot wheel has a very flat efficiency curve. Of course this economy could not be obtained if the load were constantly changing, but this is not necessarily understood to be the case when we speak of efficient governing.

Mr. Shearer has also made a vital mistake in Fig. 3 on page 732 of the Nov. 19 issue. If he had taken the case of a wheel equipped with curved vanes which reversed the relative velocity of the water through an angle of 180 deg., his conclusions would have been correct. But for a wheel equipped with flat paddles, as shown, his calculations are wrong. Neglecting friction losses, the water will strike the paddles with a relative velocity of 15 ft. per sec. and will leave with a relative velocity of 15 ft. per sec., as stated. But the direction will be tangent to the paddle and not back toward the nozzle. The absolute velocity of discharge will thus not be zero as he states, but $15\sqrt{2}$. The kinetic energy of the water leaving the paddles will hence be one-half that of the original jet. Hence the efficiency of such a wheel could never be more than 50 per cent. even neglecting all friction losses, while Mr. Shearer would have it 100 per cent. The proof of this fact is that waterwheels are not built with flat paddles, and it is for this very reason.

On the following page he asserts that the peripheral velocity of an impulse wheel depends only on the velocity of the jet. He probably does not mean this for he must know that it depends also on the relation between the size of the jet and the torque on the wheel. What he means to say is that the velocity at which the wheel should run for best efficiency depends on the velocity of the jet.

A little further down he states that the smallest diameter of impulse wheel should be at least 12 times the diameter of the jet. This factor is the common proportion, but it is not the minimum value that can be or that is used.

In the discussion of the speed of rotation of a reaction turbine he dwells on the higher peripheral velocity of the latter without any mention of the fact that the chief factor is the very much smaller diameter of the reaction turbine as contrasted with an impulse wheel for the same power and head.

And as for the next to the last paragraph on page 734, if one knows something about the subject this observation is of no value to him. If he knows nothing beforehand of the matter, he will be no better off after he has read this.

R. L. DAUGHERTY,
Professor of Hydraulic Engineering,
Rensselaer Polytechnic Institute.
Troy, N. Y.

## Color of Flame for Efficient Oil Burning

Is it possible to judge the efficiency of combustion in an oil-fired boiler furnace by observing the color of the flame? And is the color an unfailing guide for all kinds of oil used in such furnaces?

My reason for asking these questions is that there seems to be some difference of opinion among writers who have referred to this matter. One writer advises that the tip of the flame should show red. Another declares that with the proper regulation of steam, air and oil a soft orange-colored flame will be produced and will fill the furnace. A third is of the opinion that a violet color tipped with red indicates excellent combustion conditions. Still another suggests a light brown color as desirable.

Of course, it is possible that they are all correct in their statements and that the differences are due to differences in the application of the burners or in the kind of oil used. Perhaps the agent used for atomizing—whether air or steam—has something to do with the matter. In the absence of any qualifying statements as to the various conditions of operation, however, there appears to be confusion. Maybe the questions at the beginning of this letter will have the effect of bringing out information that will clear up the situation.

New York City. S. U. TUSPIN.

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Meter the boiler-feed water and weigh all the coal used in a period of a full week. If the showing in evaporation is good, or better than just good, let others in on how it is done. If bad or worse, get busy and make it at least good.

# Making a Pressure Regulator More Sensitive

By W. T. Meinzer

The writer has had some experience in improving several steam-reducing valves, and a description of the work done may be interesting. On taking charge of a plant I found that the exhaust head discharged volumes of steam at times when all of it should have been used in the heating systems. Investigation showed that the back-pressure valve was tight and operating properly. An examination of the reducing-pressure valve supplying the makeup steam showed that conditions there were not as they should be.

Large quantities of steam were used in two hot-water heaters supplying water for laundry purposes, and whenever there was a heavy draft of water from them, the reducing-pressure valve would open wide to supply the demand for more steam to heat the water. Then the pressure of the heating system would drop, and the valve would remain open until the pressure built up and forced the back-pressure valve to open before the reducing valve would close. This naturally suggested a sticking valve, but an examination did not show such to be the case.

While investigating it was noticed that the diaphragm chamber of the reducing valve was warm, and as the pipe leading to it was trapped, it was concluded that when the diaphragm lowered, the water in the chamber below it was pushed into the steam pipe and carried away, and when the pressure accumulated enough to

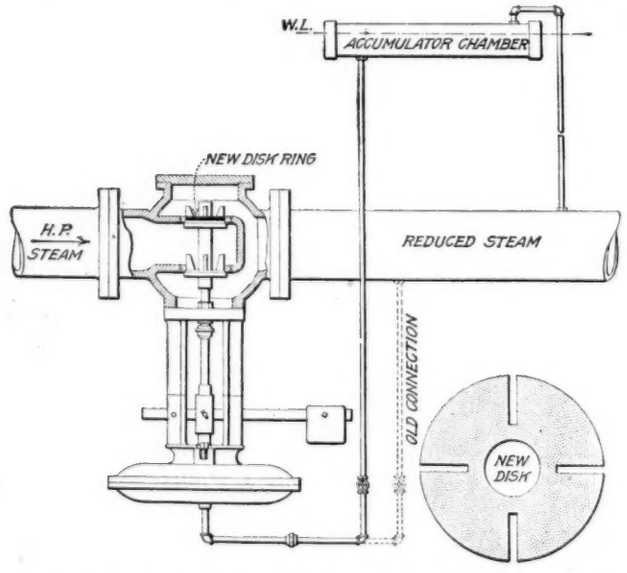



FIG. 1. CHANGED PIPING TO DIAPHRAGM AND NEW VALVE DISK

push the diaphragm up, steam took its place in the pipe and chamber.

It was further deduced that the steam, having practically no weight as compared with the body of water that had filled the pipe leading to the heating piping, made it necessary for a higher pressure to accumulate in the system before it would close the reducing-pressure valve.

To remedy this condition I made a chamber of 2-in. pipe and suitable fittings, of sufficient capacity to hold enough water to fill the diaphragm chamber and connecting piping, and installed this horizontally near the ceiling of the room and connected it from the under side at one end with the diaphragm piping and from the upper side at the other end with the reduced-pressure piping, Fig. 1. This resulted in marked improvement.

The reason for giving the water in the diaghragm pipe an increased height was to get a greater pressure

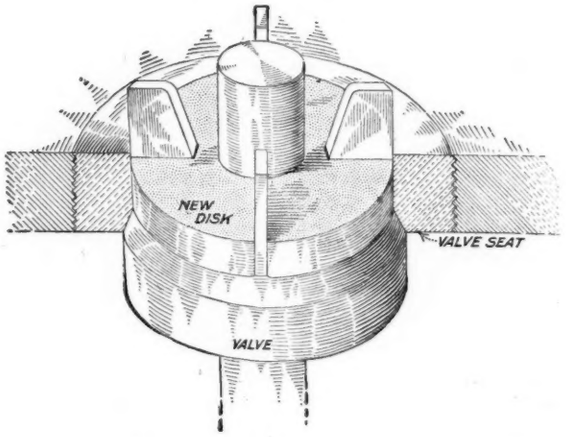



FIG. 2. APPLICATION OF NEW DISK TO VALVE

on the diaphragm in order to take up all lost motion in one direction that the 2-in. horizontal pipe afforded. It also gave sufficient capacity for the water head in it to vary but an inch or less in height and so kept the water column constant.

However, with this change the valve did not operate satisfactorily as it seemed to open too wide and showed a tendency to dance. A dashpot was tried on it, and although it stopped the dancing, it allowed the valve to open too wide and apparently become unbalanced, and to close only after considerable pressure accumulated.

The valve was taken apart again and a disk made out of a brass pump-valve plate was slipped over the valve spindle against the wings of the valve and pinned there, Fig. 2. The valve was assembled and presto! the thing was done.

It was reasoned that when the valve opened wide the steam issuing through the valve, which was a double-seated one, struck the disk forming the head with such velocity that it tended to force the valve further open and unbalanced it, as the steam issuing through the other seat met no such obstacle, and that the disk that was installed provided the resistance. The two forces then balanced each other and left the diaphragm to take care of only the pressure variation.

I am equipping all my reducing-pressure valves with this extra disk as fast as I can. The manufacturers of these valves claim that the tendency to chatter can be controlled by installing a valve in the pipe leading to the diaphragm, but this makes the valve sluggish in action. Furthermore, it has often been found that such valves have been almost closed by the attendants in their efforts to stop the nuisance. A reducing valve operating under such a condition is a menace, as the pressure might build up enough to burst radiators, feed-water heaters, etc., that are intended for low pressure only.

# INQUIRIES OF GENERAL INTEREST

**Loosening Clinker from Furnace Walls**—How can accumulations of slag and clinker be removed from the fire-brick side walls of a boiler furnace? C. M.

Such accumulations will usually be loosened from the furnace walls in a few hours by placing a narrow pile of lime, salt or oyster shells against the clinker and maintaining a hot fire.

**Constancy of Ratio of Current Transformer**—Does the current ratio of a series or current transformer change with the line voltage? D. J. N.

The current ratio does not change with the line voltage if the normal current is not exceeded. The voltage across the primary is changed only when the current is changed. Consequently, if the line voltage were to be increased, but the load current reduced to its former value, the increase in voltage would have no effect on the transformer.

**Current Density in Busbars**—What is the allowable current density in switchboard busbars? C. H. L.

Two conditions control the current density which should be used in conductors. One is loss in power in the conductor and the other the rise in temperature of the conductor caused by that loss. The former is at the discretion of the designer, the latter is determined by the ultimate temperature which it is safe to use. A density of 1000 amperes per square inch is usually considered to be a safe one.

**Rated Size of Boiler for Given Indicated Power**—What horsepower or size of boiler should be ordered to supply steam to an engine that is to develop 140 indicated horsepower with an economy of 28 lb. of steam per indicated horsepower per hour? W. R. T.

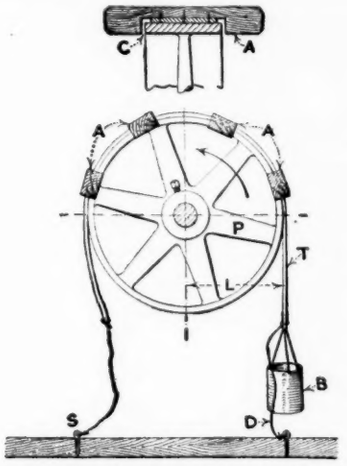
Ordinary types of boilers are commonly rated in sizes by allowance of 10 sq.ft. of heating surface per boiler horsepower, and each boiler horsepower is assumed to be a steam-generating capacity that is equivalent to the evaporation of 34½ lb. of water from and at 212 deg. F., when there is ordinarily good fuel, firing and draft. With the ordinary temperature of feed water and pressure of steam generated, this rate of evaporation is equivalent to about 30 lb. of water evaporated per hour. To supply steam for the feed pump and to cover such ordinary losses as by waste, leakage and condensation, temporary lowering of the feed-water temperature and reduced efficiency of heating surfaces for want of cleaning, the normal boiler horsepower capacity should be at least 25 per cent. greater than the engine's requirement for steam. Hence for development of 140 i.hp. with an economy of 28 lb. per i.hp. per hour, the rated boiler capacity installed should be not less than $(140 \times 28 \div 30)\ 1.25 = 163$ boiler horsepower.

**Proximate Analysis of Coal**—What is meant by the proximate analysis of coal, and how is it performed? S. A. D.

Proximate analysis of a fuel is the approximate determination of the proportions of fixed carbon, volatile matter, moisture and ash content. Progressive heating separates these parts and weighing the remainder at each stage affords data for computing the various percentages. At a temperature of 250 to 300 deg. F., all the moisture will be driven off. Further heating to a dull-red heat will remove the volatile matter, and at a white heat the carbon will unite with oxygen to form $CO_2$, leaving the ash as final residue. For ordinary boiler-room purposes the apparatus required consists of a crucible 3 to 6 in. diameter, with a cover of refractory material, and an apothecary's scales for performing the successive weighings. For handling the crucible a good crucible tongs should be at hand. For the heating the most available means will answer, as the boiler furnace itself. The crucible may be held in the furnace with the tongs or may be supported on an old shovel. For the first heating, to drive off the moisture, the crucible may be set on the dead plate just inside of a fire-door. A blacksmith's forge or a large enough gas flame may be used for the whole range of heating. To begin with, the weight of the empty crucible should be taken so it may be deducted from the final weight to obtain the weight of ash.

**Brake Test of Small Gas Engine**—How could a test be made of the brake power developed by a small gas engine that makes 300 r.p.m.? J. E. B.

One of the simplest and best forms of brake for testing the power of a small motor is shown in the illustration. A piece of flexible belting is thrown over a pulley *P* of any convenient size secured on the shaft of the motor. To keep the belt from sliding off the face of the pulley it may be tacked fast to light notched cleats *AA* that allow a little clearance at the edges of the pulley rim as indicated at *C*




STRAP BRAKE FOR TESTING SMALL MOTOR

Having rotation of the pulley in the direction indicated by the arrow, the tendency for the belt to become wound on the pulley is resisted by placing weights in a bucket *B* or, other convenient receptacle, attached to the side *T*. As a precaution against accident the ends of the belt are secured to the floor at *S* and *D* by stout flexible cords and these cords must be slack when the weight at *B* is observed for use in the computation. When the cleats and the ends of the belt are in position to balance without tendency to rotate the pulley in either direction, the power developed by the motor in sustaining a weight *B* with slippage of the belt on the pulley would be the same as though the same weight were being raised at the same speed by the belt winding on the pulley. If the distance *L* represents the radius of the pulley plus one-half the thickness of the belt, in feet, the length of belt that would thus be wound up and the height the weight would be raised per revolution would be *L* feet $\times$ 2 $\times$ 3.1416, and this multiplied by the r.p.m. and value of the weight in pounds, would be the foot-pounds exerted per minute.

For example, if $L = 6\frac{1}{2}$ in., r.p.m. = 300, and total weight B = 12 pounds, the energy developed would be $\frac{6\frac{1}{2}}{12} \times 2 \times 3.1416 \times 300 \times 12 = 11{,}545.4$ ft.-lb. per min., or $11{,}545 \div 33{,}000 = 0.34$ brake horsepower.

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[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

# Coal Saving by the Scientific Control of Steam Boiler Plants*

By D. Brownlie

THE author has been associated for about ten years with the investigation on scientific lines of the working of every description of steam-boiler plant, and in the present article it is proposed to give the average figures for 250 typical steam boiler plants, with the object of supplying accurate data as to the tremendous national economy that can be effected by the adoption of scientific methods in the boiler-house.

In the burning of coal for the generation of steam, the loss because of lack of scientific methods is hardly realized and, apart from the national point of view, offers to the individual firm a means of most substantial economy in running expenses.

It is not possible to find out what is the exact amount of coal used for the production of steam for purposes other than power, there being, for example, no statistics available showing the number of steam boilers at work in Great Britain.

The author proposes therefore to assume, until further information can be obtained by a proper engineering census of the country, that the total amount of coal used for steam generation in the United Kingdom is between 75 and 100 million tons per annum, being 60 to 70 million tons for power production and 15 to 30 million tons for purposes other than power, corresponding to 40 per cent. to 53 per cent. of the total coal used, and is of the opinion that the 250 boiler plants to be dealt with in the present article are really representative of all the boiler plants of the country, and that the results of such a very large number of exhaustive scientific investigations carried on continuously during the last eight years will enable us to judge with considerable accuracy as to the saving that can be obtained by improving the present methods of burning 75 to 100 million tons of coal per annum for steam generation. These plants are situated in England, Ireland, Scotland and Wales, and comprise all sizes of plants with annual coal bills from 750 to 70,000 tons, and the working pressure varied from 12 to 200 lb. per square inch.

The fuels used are of every possible description from the highest qualities down to inferior fuels, including refuse coal mixed with shale, pit sweepings, washer settlings, etc., as well as coke and coke breeze.

As a further support for the claim that these 250 steam-boiler plants are typical of the whole country the author has, during the past ten years, inspected, without testing, probably several thousand boiler plants, and finds that these are all being worked on about the same general lines. (A few figures are taken from the table of the average performance of these 250 plants.)

| | |
|---|---|
| Water evaporated per square foot of grate area per hour | 137.4 lb. |
| Water evaporated per pound of fuel | 6.56 lb. |
| Equivalent evaporation from and at 212 deg. F., per pound of fuel | 7.46 lb. |
| Equivalent evaporation from and at 212 deg. F., per 1,000,000, B.t.u. | 631.0 lb. |

A detailed test of the plant was made for one working day, and a further test of one week was also carried out as a check on the figures for the fuel used and the water evaporated, and to ascertain the weekly running conditions, including all week-end losses due to stoppage of plant, etc. The object of the test was to find out the exact normal everyday working conditions of the plant, particularly as regards efficiency and the cost in coal for the production of unit of steam (evaporation of 1000 gal. of water), so that a scheme of reorganization could be devised for the more economical production of steam. In every case the boiler-house staff worked the plant as usual.

*Type of Boiler*—The 250 plants had a total of 1000 boilers, comprising 935 "Lancashire" boilers, 36 modern "tubular" boilers, 17 "egg-ended" boilers, 6 "Cornish" boilers, 1 "marine" boiler, 2 "vertical" boilers, and 3 "patent" boilers difficult to classify. It would be most interesting to know the exact number of each type of steam boiler at work in the country, although there is no doubt that the chief type in use is the "Lancashire."

*Amount of Fuel Used*—The average shows 20.9 lb. of fuel burnt per square foot of grate area per hour, referring, of course, to the average amount burnt per hour per working day, and not to the amount for any particular hour. This figure is considerably below what is possible on a boiler plant run on modern lines, which would burn something like 25 lb. to 30 lb. per square foot grate area per hour with the average quality of fuel. The boiler plants of the country are working under very easy conditions in this respect, and much more fuel could be burnt per boiler. Figures for fuel consumption depend largely on the quality of the fuel. Thus a good quality washed coal of, say, 13,000 B.t.u. and 7 to 8 per cent. ash could easily be burned economically at the rate of 35 lb. per square foot per hour, whereas purely refuse coals would only give about 15 lb. Coke of good quality can be burnt at the rate of 22 lb. per square foot grate area per hour and coke breeze about 15 pounds.

It will be understood that a boiler plant can be worked just as efficiently with a low fuel consumption as with one of normal figures, but the trouble with many boiler plants is that the increased fuel consumption is required to give more steam but cannot be obtained because of lack of scientific methods.

*Analysis of Fuel Used*—In only four cases was the fuel purchased scientifically, guided by the determination of the heating value, and analyzed in an accurate manner. In certainly over 90 per cent. of cases the fuel was purchased in a general rule-of-thumb manner, without any accurate knowledge of its real value. It is perhaps hardly necessary to point out that a firm that buys fuel buys heat; that, other things being equal, the fuel that contains the most heat is the best value for the money, and that it is impossible to get the best results by buying and using fuel completely in the dark as to its heating value. The author is of the opinion that certainly not 5 per cent. of steam users buy their fuel on scientific lines. These remarks hardly, of course, apply today because of the abnormal conditions due to the war and the fact that the fuel supply is so restricted that the consumer is glad to get hold of any kind of fuel, but the point is that previous to the war these remarks hold good, and as far as can be seen will also hold good when the war is over unless we alter our methods. It would hardly be possible to give a better example of the general lack of scientific methods in vogue in our industries generally than that of the buying and selling of fuel. Certainly well over $250,000,000 worth of fuel per annum is purchased for steam-raising purposes by methods which would be ridiculed in most other forms of buying and selling.

The author's experience is that in normal times the average firm could save 7 per cent. to 10 per cent. of the fuel bill alone by buying on scientific lines—that is, by buying the coal or other fuel which was the best value under the conditions of the given steam-generating plant.

*Quality of Fuel*—The average for the 250 plants shows 11,822 B.t.u. and 11.5 per cent. ash, which includes almost every description of coal and coke varying in quality from 7000 to 14,000 British thermal units.

As regards coke, a good average sample shows about 12,000 B.t.u. with 12 per cent. ash, while a good sample of coke breeze shows 9000 to 10,000 B.t.u. and 15 to 20 per cent. ash. The great trouble with coke and coke breeze is the amount of moisture contained in them. Good samples should only contain about 5 per cent. and certainly not over 8 per cent.

*Abstract from an article in *Engineering* (London).

Many samples, however, contain regularly 20 per cent., which is a most serious matter from the point of view of economy. Thus coke is being used with the following analysis: 10,000 B.t.u., 15.5 per cent. ash, and 14.5 per cent. water.

*Method of Firing*—In 190 cases (76 per cent.) hand firing was in use, with an average net working efficiency of 57.8 per cent., as against 60 cases (24 per cent.) of mechanical firing with an average net working efficiency of 61.4 per cent., representing eight different makes of mechanical stokers.

There is a very considerable conflict of opinion among steam users as to the advantages or otherwise of mechanical firing as compared with hand firing. As seen from the figures, 190 cases of hand firing are giving slightly inferior results to 60 cases of mechanical firing. One factor to be taken into account is the cost of upkeep of mechanical stokers, but taking an average for the whole country this increased cost is probably equal to the saving in labor of hand-firing. It is not realized how bad is the general working performance of the mechanically fired steam boiler plants, and we are so used to reading the remarkable results of boiler trials in catalogs and advertisements of some mechanical-stoker firms that an average efficiency of 61.4 per cent. under actual working conditions comes somewhat as a shock.

Taking boiler plants generally it is very difficult to decide as to whether hand or mechanical firing is preferable. In the case of "tubular" boilers with large grate areas mechanical firing is undoubtedly the best, and very good results can be obtained provided that the mechanical stokers have constant skilled attention and supervision. In the case of "Lancashire," "Cornish," "marine," and similar types of boiler with the ordinary narrow grate the matter is very complicated, and it is more difficult to get good results with mechanical firing as compared with "tubular" boilers.

Obviously, a great many factors enter into the case, such as quality of fuel, amount of steam required and whether the demand is fluctuating or not, the quality of the supervision, and so on. A given type of mechanical stoker may work well under some conditions and badly under other conditions.

One can only say that with both hand and mechanical firing 75 per cent. to 82½ per cent. efficiency can be maintained, and a very careful examination of the general working conditions of the plant must be made before deciding for hand or mechanical firing, and if the latter, which type of stoker. The usual practice is to install mechanical stokers or pull them off again in the most rule-of-thumb manner, both mechanically fired and hand-fired plants receiving but little scientific attention and supervision.

*Measurement of Boiler-Feed Water*—Out of the 250 plants, in 25 cases only was there any apparatus installed on the plant for determining regularly the water evaporated —that is, the amount of the steam produced. Further, out of the 25 cases, several of the water meters in use were certainly not accurate.

A boiler plant is, of course, a little factory in itself, in which the finished product is steam, and unless there is some form of water-measuring apparatus at work to regularly check the performance of the plant, there is bound to be some loss. How much, is merely a matter of accident. The author is of the opinion that not 5 per cent. of the boiler plants of the country are fitted with accurate water-measuring apparatus in regular use.

*Amount of Water Evaporated*—Although the evaporation of a boiler naturally depends on the quality of the coal used, there is no doubt that the boiler plants of the country generally are evaporating much less water than would be possible under proper scientific methods of control. Probably all the steam produced in Great Britain today could be obtained much more economically with 25 per cent. less boilers. The author has reorganized many boiler plants and doubled the evaporation per boiler per hour, which means that with large plants of 30 "Lancashire" boilers or over no less than 15 or more boilers could be shut down. There are hundreds of boiler plants at work which are always more or less short of steam, and in which, by a very moderate amount of reorganization, the output of steam could be considerably increased, making a great difference in the efficiency of the general running of the factory. Thus, in a well-managed plant and with average quality of coal, a "Lancashire" boiler, 30 x 8 ft., can evaporate easily 850 gal. per boiler per hour, an increase of 62 per cent. of steam output as compared with average figures.

*Feed-Water Examination*—With regard to the scale troubles, out of the 250 plants 75 either had no trouble at all or only very slight, 155 were what might be described as "usual" or "medium," while 8 cases could be described as "chronic."

With regard to the methods in use for coping with these difficulties, in 182 cases there was no treatment at all (75 cases where no treatment was required, and 102 cases where the scale was simply allowed to form, and was then chipped off again). In 43 cases a water-softening plant was in use, and in 25 cases some form of boiler composition was being added to the boiler-feed water.

In the case of water-softening plants, out of the 43 cases in only 15 cases was the softening plant being worked efficiently and controlled by regular daily analysis. In one or two cases the water was no better, or even worse as regards the presence of scale-forming elements, after passing through the water-softening plants, due, of course, to wrong proportions of chemicals being used.

In certainly well over 50 per cent. of cases where a water-softening plant is installed the proper attention and daily analysis are carried out for a few weeks, and then very soon the plant is left to work by itself, a charge of chemicals being added every day merely as matter of habit, without the least attention being paid to the results, and the variation in the quality of the water. The average hardness of boiler-feed water for the whole country, including treated and untreated water, is probably about 12 grains per gallon. On the previous calculation of a total weekly evaporation of 2,128,000,000 gallons to 2,845,000,000 gallons, this would mean that all the boiler plants of Great Britain have deposited in them weekly no less than 1,600 tons to 2,200 tons of solid material, most of which forms scale.

With regard to boiler composition, in addition to the 25 cases mentioned, the author has analyzed many other samples of boiler compositions. In most cases these compositions are found to consist simply of caustic soda or soda ash, or mixture of these, together with some vegetable product, very often a crude form of tannic acid. Some of these compositions can only be described as extraordinary. Thus one of them had 95 per cent. water, 0.5 per cent. soda ash, and 4.5 per cent. tanyard refuse. If, however, they vary in composition, they seem to show a great similarity from the point of view of exorbitance in price and failure to prevent scale. Most of their "good" effects are due to the caustic soda, and if it is desired to put caustic soda into boilers (which is not to be recommended), this can be purchased at about one-tenth of the price.

As regards corrosion, only a few cases were observed due to "peaty" acid in moorland water, to excessive salt, to sulphuric acid in pit water from pyrites in the coal, or to accidental causes such as mineral acid in the water supply due to the effluent from some other works.

*Economizers*—Out of the 250 plants, 155 were fitted with economizers, the other 95 plants having no means of utilizing the waste heat from the boiler flues.

Taking the 155 plants fitted with economizers, the average saving is 11.4 per cent. of the coal bill. The highest figure found was 19 per cent. on a cotton-mill plant. The ordinary figure obtained on a well-managed plant is 15 to 20 per cent. saving, depending on the conditions.

*Estimation of* $CO_2$—Out of the 250 plants, 225 were not equipped with $CO_2$ recorders, 15 were equipped with recorders in fairly good running order, and 10 were equipped, but the machines were out of order. One striking fact is the very large number of boiler plants met with that have been fitted with $CO_2$ recorders, and have been forced to discontinue using them because of their complicated character. It is probably correct to say that the $CO_2$ recorder has given

more trouble than any other instrument or appliance used in the boiler house.

In order to get economical results it is, of course, necessary to have some form of $CO_2$ recorder on a boiler plant, but it must be used with discretion. To get the best results it is essential to have a high percentage of $CO_2$, say between 12 and 16 per cent., but it does not at all follow that a high figure necessarily means high efficiency. The figures obtained for $CO_2$ by connecting a $CO_2$ recorder on the 250 plants during the tests were as follows:

| | |
|---|---|
| 1. Very good, plants showing over 12 per cent. $CO_2$ | 4 |
| 2. Good, 10 to 12 per cent | 17 |
| 3. Medium, 8 to 10 per cent | 64 |
| 4. Poor, 5 to 8 per cent | 144 |
| 5. Very bad, under 5 per cent | 21 |

That is, 66 per cent. were below 8 per cent. The best record found was 14 per cent. average, and the worst 3.5 per cent.

*Black Smoke*—Following are the particulars as regards black smoke for the 250 plants:

| | |
|---|---|
| 1. Good; practically no smoke at all | 65 |
| 2. Fairly good | 62 |
| 3. Medium | 75 |
| 4. Bad | 43 |
| 5. Chronic; almost continuous black smoke | 5 |

Out of the 250 plants, 30 were fitted with some form of patent smoke preventer. Most of these smoke preventers consist of some arrangement for allowing air to pass up the back of the bars so as to add excess air to the smoke on the bunsen-burner principle. In practice they give only the most moderate results, and the way to stop black smoke economically is obviously to consume it in the furnaces.

It is really quite a simple matter to prevent black smoke and to get increased economy at the same time. It should be noted that, although a highly efficient plant will in all cases be practically smokeless, it does not follow that a plant having bad black smoke is necessarily very inefficient. For example, a plant may be working very well in every respect, giving, say, 13 per cent. or 14 per cent. $CO_2$. A trifle less air going through the fires will result in smoke, and perhaps 16 per cent. $CO_2$; but when in this condition the plant would be very much more efficient than many other plants that are smokeless due to a large excess of air passing through the fires.

*Boiler Pressure*—In the 250 plants of all varieties the working pressure was from 12 to 200 lb. numerically as follows:

| | |
|---|---|
| 1. Under 60 lb. average working pressure | 45 |
| 2. Between 60 lb. and 80 lb. | 71 |
| 3. Between 80 lb. and 100 lb. | 55 |
| 4. Between 100 lb. and 120 lb. | 35 |
| 5. Between 120 lb. and 160 lb. | 37 |
| 6. Over 160 lb. working pressure | 7 |

As most engineers are aware, the engines of the country are, on the whole, working at much too low a pressure from the point of view of economical utilization of steam, and the results show 46 per cent. of boiler plants working at less than 80 lb. pressure.

*Superheaters*—Out of the 250 plants, 80 plants were fitted with superheaters, which includes 55 plants only partially fitted. The value of superheating is very little realized, either from the point of view of partial superheat of, say, 75 deg. F., to avoid condensation losses in the steam pipe circuit, or from that of complete superheating with a view to economical utilization of steam in the engines or turbines.

*Annual Coal Consumption*—In this respect the 250 plants were representative of different-sized plants, being divided as follows:

| | |
|---|---|
| 1. Under 1,000 tons per annum | 10 |
| 2. Between 1,000 and 2,000 tons | 26 |
| 3. Between 2,000 and 4,000 tons | 62 |
| 4. Between 4,000 and 7,000 tons | 54 |
| 5. Between 7,000 and 10,000 tons | 33 |
| 6. Between 10,000 and 20,000 tons | 41 |
| 7. Over 20,000 tons per annum | 24 |

*Steam or Power Used as Auxiliary to the Production of Steam*—Out of the 250 plants, 127 were using steam or power as an auxiliary to the production of steam, 93 being steam jets under or over the bars, 32 as induced draft, and 2 as forced draft. Out of the 127 cases the average amount of steam so used was 4.7 per cent. of the production in the boilers. With regard to induced or forced-draft fans, the average is approximately 2½ to 3 per cent. of the production. With steam jets the amount varies very considerably, being anything from 1 to 20 per cent. of the production, the average on the 93 plants being 5.6 per cent. Where the jets are used as the sole means of obtaining a draft, as in some types of patent fire-bar and mechanical stokers, the amount is rarely under 5 per cent. and may be as high as 12 per cent. The author has come across one or two extraordinary cases. Thus one type of steam-jet apparatus had no less than sixty ⅜-in. steam nozzles working at 100 lb. pressure per "Lancashire" boiler, using 1302 lb. of steam per hour, whereas the total evaporation of the boiler was only 6861 lb., so that the amount of steam used was nearly 19 per cent. of the production. In the types of stokers using steam jets to cool the bars the amount is generally between 2 and 4 per cent.

Very little attention has hitherto been given to this question of auxiliary power. In many cases where some form of mechanical stoker or fire-bar has been installed, on investigation the amount of steam used under the bars has been found to be equivalent to the cost of a complete new outfit every twelve months.

Assuming that 2.4 per cent. of the steam production is used in auxiliaries, then the coal consumption of all the boiler plants of the country (that is, 75,000,000 to 100,000,000 tons) the amount used in this way is 1,800,000 to 2,400,000 tons per annum.

*Efficiency of Plant*—The average working efficiency for the whole 250 plants tested is 60.09 per cent.; that is to say for every 100 lb. of coal put into the boiler fires 60.09 lb. is being used to produce useful steam, the other 39.91 lb. being wasted, and 61 per cent. of the plants are working with an efficiency of less than 60 per cent., and that only 9.6 per cent. of the plants exceed 70 per cent. efficiency. There is a general impression that bad working results are due to "old" plants, and that a new plant is much more efficient. This is, of course, a fallacy and due to the fact that boiler plants have never been regarded from a scientific point of view. A given boiler plant is obtaining efficient results, first of all, because of correct design and, secondly, because of careful attention to the working. The age of the installation has nothing to do with the efficiency of the results except that in a casual sort of way a plant of recent erection may have a few more economizers, and superheaters may be installed. Generally speaking, modern boiler plants are no more efficient than plants erected, say, ten years ago, because the science of economical steam generation is no more understood now than it was then. Thus 21 paper mills, almost all of which are old plants, certainly on an average fifteen years, are giving more efficient results than 22 explosive factories that have been erected on the most "modern" principles and which, on an average, are only about three years old. The efficiency of the boilers of the explosive factories is the best of all, but the amount of auxiliary steam used is no less than 5.68 per cent., as compared with only 2.4 per cent. for all industries. Thus the modern plants are wasting much more fuel in this respect than the older plants, and some of the newest of these plants show a shocking lack of economy, using even 15 per cent. and over of the steam produced, when 3 per cent. is ample for the most efficient results.

## Summary of Results

The detailed analysis of the results have been quite sufficient to show that the general methods of steam generation in this country are out of date.

No attempt is made to purchase fuel on scientific lines, on the actual heating value of the fuel supplied and its suitability for the particular conditions of the given boiler plant. No check is kept on the cost of production of a unit of steam and on the general performance of the plant. Thousands of factories are short of steam in spite of the fact that a very moderate amount of reorganization of the boiler plant would give all the extra steam required from the same number of boilers and the reorganization would be paid for in a few months by increased factory produc-

tion. Thousands of boiler plants are being worked under shocking conditions as regards attention to repairs and upkeep conditions which would not be tolerated for a moment in connection with engines and general machinery.

The reason of this deplorable state of affairs is first because the question of the economical generation of steam is essentially the business of a specialist, comprising a combination of technical chemistry and engineering quite outside ordinary practice. It seems very probable that the conditions of steam generation in this respect are much the same all over the world. The author has examined a number of steam boiler plants in France, and the general working conditions appear to be very similar. In the United States the average working efficiency does not seem to be more than about 60 per cent., on a coal bill at the present time of certainly over 300,000,000 tons per annum.

Secondly, in Great Britain at any rate, the trouble is due to conservatism, to a general disinclination to apply modern methods of applied science and organization, a characteristic that applies to many other national questions besides that of coal economy.

### Savings To Be Obtained

The average net working efficiency of the 250 plants is 60.09 per cent., which the author contends is a typical figure for all the plants of the country.

A steam boiler plant run on modern scientific lines will give results of 75 per cent. to 82 per cent. efficiency with ordinary steam coals or coke, depending on the particular conditions of the plant. With purely refuse fuels the best efficiency possible may be only, say, 65 per cent. to 70 per cent., but for all practical purposes 75 per cent. net working efficiency may be taken as the average figure to be obtained on continuous performance. This figure is based on the author's ten years' experience of scientific boiler-plant work, which includes the reorganization of dozens of boiler plants, and is not a theoretical assumption. Thus, in the 250 plants, 2 plants are already working at over 80 per cent. efficiency, 9 between 75 and 80 per cent., and 13 between 70 and 75 per cent., and the general working conditions of these plants are roughly no different than the remaining 226 plants which are only working at about 57 per cent. efficiency.

Turning now to the amount of coal to be saved, taking first the exact figures of the actual 250 plants, the total amount of coal burnt per annum on these plants, consisting of 1000 boilers, is 2,166,000 tons, with an average efficiency of 60.09 per cent. If these plants were reorganized on modern scientific lines and run on an average efficiency of 75 per cent., the annual saving would be, say, 430,000 tons.

Assuming that the 250 plants are typical of the thousands of boiler plants of the country, then if all these plants were brought up to date and run at 75 per cent. efficiency, the saving would be 20 per cent. or no less than 15 to 20 million tons of coal per annum.

Even in the more up-to-date industries the aggregate saving possible in very large. Thus, taking the case of electric generating stations, which are supposed to be very efficient, it will be no exaggeration to say that the average saving possible in all the 600 or more power stations in the country is 10 per cent. of the fuel bill by the more economical generation of steam. What is required at once is that a quick survey should be made of all the boiler plants of the country by the few real experts on the question. This work cannot be done by amateurs or by people who are unused to technical conditions and organization. When such a rapid survey has been made an immediate reorganization of the largest and most wasteful of the boiler plants of the country should be carried out, together also with the utilization of the large stocks of refuse coal at many collieries for boiler plants working under easy conditions as regards steam output. There is not the slighest doubt that at least 500,000 tons of coal per annum could be saved in this way, commencing in six months' time, and the necessary labor and material for the reorganization would be very small in comparison to the national saving obtained.

The larger question of a great national scheme of economical utilization of our coal resources requires the most careful and thorough investigation, with a vast amount of experimental and research work, and we have urgent need of every experienced man in the country to unite and concentrate upon it. The immediate steps toward the reorganization of the largest and most inefficient of those plants which produce a large amount of steam for purposes other than power production, should be undertaken so that the reorganization would fit in with the future and large scheme of national coal economy to be applied to the whole country.

## Helps Toward Saving Coal

The New England Confectionery Co., assisted by the Factory Fuel Committee, has made many changes that will promote the conservation of coal and has drawn up a set of instructions concerning the regulation of room temperatures, lighting and factory inspection. This committee is composed of the superintendent, master mechanic, chief engineer and room foremen of various departments, numbering in all fifteen members. Meetings are held weekly and the various suggestions of each member are taken up and discussed. Bulletins issued by the committee are placed in various places through the factory.

The latest suggestion for the saving of light and heat has been to place in the various rooms cards requesting the workmen not to waste light or overheat the rooms. The larger cards are put in conspicuous places where they are bound to be seen and the smaller ones, having eyelets, are fastened to the cords of pull-sockets on electric lights.

The more important reforms have been to change from live to exhaust steam on one dryroom, two continuous service hot-water heaters, five corn-syrup heaters, ten revolving pans (fifty more are to be connected), eight mogul heads where steam is used for steaming out, seven cream coolers where it is used for steaming out, two steamers for lozenge cutters, the steaming out of corn-syrup barrels, and the steaming out of five vacuum pans used for cooking. It is found that where exhaust steam is used for steaming out it gives better results than live steam, the entrained water serving to rinse the surfaces.

Removable coverings have been put in the flanges of all pipes where they were not previously covered; mechanical boiler-tube blowers have been installed and the boiler tubes are blown three times daily; special attention is given to combustion and to flue-gas analysis; draft gages and water meter are ordered and it is hoped will soon be installed; engines are indicated at least once a month.

The instructions for light and heat are: During all weather requiring heat, outside doors are to be kept closed as much as possible; elevator doors at the basement and street floors to be kept closed and all elevator doors to be kept closed during cold weather; bridge doors and double swing doors that are installed for the prevention of draft are to be kept closed and in working order; windows, except a few that need to be opened frequently, are to be kept closed and locked. The company intends to supply sufficient lighting, but economical use is expected.

The Fuel Committee has recommended standard temperatures for the packing rooms and offices. Heads of departments are expected to maintain these temperatures by making requests upon the department of heat, light and power for more or less steam or valve regulation.

To further these matters, Fred Allen, under the supervision of Mr. Lowe and the Fuel Committee, has been appointed inspector. He will inspect and collect temperature logs and otherwise assist in the regulation of temperature He will note any errors or omissions in the carrying out of directions and regulations. A second inspector may be appointed later to assist in carrying out these measures to make the purpose of the company in fuel economy effective.

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A new method of treating peat and forming it into briquets has been invented by Samuel C. Davidson, of Belfast, says *The Engineer*. His method consists in putting back into the peat certain oils washed away from it by the weather, previously disintegrating it and mixing it with 15 per cent. of pitch dust. The paste thus formed is pressed into square blocks which will burn well.

## U. S. Navy Steam Engineering School

The United States Navy has established on the grounds of Stevens Institute, Hoboken, N. J., a school for the training of Engineering Officers for the Naval Auxiliary Reserve. The graduates of this school will be the officers in the engine rooms of the transport and supply ships of the Navy. The qualifications for entrance are as follows: (1) 21 years to 40 years of age; (2) thorough ability and officer-like character; (3) completion of mechanical engineering, or electrical or civil engineering course in which stress has been laid on steam engineering, at "recognized" technical colleges, or possess an education and experience adjudged to be the equivalent thereof; (4) be able to pass the physical examination for Naval Officers.

The course consists approximately of five months, divided as follows: One month military training at Naval Training Camp, Pelham Bay Park, N. Y.; six weeks of technical instruction at the U. S. Navy Steam Engineering School, Hoboken, N. J.; six weeks practical training on board ships and in shops in the vicinity of New York; one month final instruction at U. S. Navy Engineering School.

Applicants will be inducted into the Navy as apprentice seamen and upon qualifying for admission to the school will be rated as chief machinist mates at a salary of $83 per month and in addition lodging and subsistence. Graduates will be commissioned as ensigns in the U. S. Naval Reserve Force. The salary of an ensign at sea is $155 per month if without dependents, and $185 if having dependents.

Applicants for admission should apply to Ensign C. L. McIntyre, Assistant Mobilization Inspector, Eastern Division, 225 West 42nd St., New York, N. Y. Men already in the Naval Service and properly qualified should apply for admission to the school to the Commandant of the Naval District in which they are stationed, via their commanding officer.

## Eastern New York Power Companies Coal-Saving Record

Coal saving at the rate of 5000 tons a month has been effected by six power companies of eastern New York through joint operation and the use of water power heretofore wasted, undertaken at the suggestion of the Fuel Administration. This coal conservation was effected without a change in existing equipment or additional cost to the power companies, and the success of the plan has been so marked that the companies interested are anxious to continue it.

The companies which combined and carried out the plan through a joint committee made up of their regular organizations, serve what is known as the "Capital District," including the cities and towns of Albany, Troy, Schenectady, Amsterdam, Mechanicsville, Cohoes, Saratoga, Glens Falls and adjacent territory. In the hands of the joint operating committee and using the available resources of six power companies, a two weeks' test was begun October 23. In that period electric energy equal to that generated by burning 2450 tons of coal was developed from existing equipment, and the natural river flow which otherwise would have gone to waste. The generating companies were thus able to market heretofore unused power, and the coal-burning companies were able to get power at a saving over their own costs.

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The standardization of shafting sizes is receiving the attention of the A. S. M. E. committee, consisting of Charles M. Chapman, chairman; George N. Van Derhoef, Hunter Morrison, Louis W. Williams and R. E. Nelles (nonmember). It was originally intended that this standardization work should be undertaken primarily as a war measure. The tone of the replies to letters sent to the principal rolling mills and transmission machinery manufacturers have, however, encouraged the committee to continue with its work with undiminished effort. It seems that a great economy of steel and storage space can be readily effected by such standardization.

## Electric Welding in Shipbuilding

Reduction of time and labor in shipbuilding by the use of electric welding as a substitute for riveting is being made the subject of experiment at an American yard, a full-sized hull being built for this purpose. The cost of the process alone will not effect much saving, but there would be a saving in templet making, marking, punching, and fitting the plates together so that the holes will match; also in the cost of shipping plates from the mill to the fabricating shop, and thence to the yard, in cases where the shop and yard are separate. It is estimated that on a 10,000-ton ship there may be a saving of a month in time and $100,000 in cost.

The hull will be assembled rapidly by spot welding, making an inclosed structure in which men may work in any weather. These spot welds to be about 10 in. apart, made with a yoke riveter of 5½-ft. gap, slung from a crane. With the parts thus assembled and held together, arc welding will be employed to close all seams, making the structure strong and water-tight. A considerable reduction in weight of steel will result from the omission of rivets. In the test hull about 25 per cent. of the work will be riveted and 75 per cent. welded for a comparison of results. The tests will be made by filling the hull with water, shifting the supports beneath it, and then noting the deflections and distortion, and measuring the stresses by means of strain gages. —*The Engineer (London).*

## Motion Picture to Show Methods of Saving Coal

Apropos of the movement for the conservation of fuel is the announcement of a motion picture entitled "Coal Is King," produced by the Ford Motor Co. This picture, taken under the direction of and from the scenario by Robert June, mechanical engineer, Diamond Power Specialty Co., Detroit, Mich., treats the subject very thoroughly. Good and bad methods of firing, losses from leaky steam pipes, uncovered pipes and leaky steam traps, and the use of $CO_2$ recorders are brought out clearly. The necessity for keeping the boiler surfaces clean is emphasized and pictures of scale and soot removal are shown. Losses caused by firing boilers too much above or below rating and losses caused by cutting in stand-by boilers too early or too late are pointed out.

The Ford Motor Co. offers this picture to organizations such as chambers of commerce, A. S. M. E. and N. A. S. E. for exhibition to power-plant operators. Much good can come from seeing it, and there should be a ready response to the offer. At present a great many dates of exhibition have been closed, several states having been booked solid. All communications relative to date of exhibition are to be addressed to Robert June, who is supervising the distribution for the Ford company.

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H. I. Rogers, in speaking before the Western Section of the British Institution of Electrical Engineers from the standpoint of the manufacturer, has stated that perhaps the most important cause of the failure or extremely unsatisfactory state of affairs of the British electrical industry has been the excessive and unnecessary competition between different manufacturers. Electrical apparatus, it is pointed out, is inherently cheap if manufactured under right conditions. All parts should be produced on a repetitive basis, and if so, quality can be of the highest and conditions of the workers can be of the best. This, however, can only be done if the purchasing public will buy the resulting apparatus. The consumer, it is held, must standardize his requirements, while the manufacturer must produce apparatus that will stand the acid test of service. The best-designed appliances under proper conditions of manufacture cost no more than apparatus of poor design. Under these conditions the industry it is held would be profitable to the workers and insure good wages; it would be profitable to the manufacturer and insure financial stability, and profitable to the consumer because it would insure him machinery of good quality at a reasonable cost.

## New Publications

THE J. E. ALDRED LECTURES ON ENGINEERING PRACTICE. Published by Johns Hopkins Press, Baltimore, Md. 236 pages; numerous illustrations. Price, $1.

These lectures, which were delivered at Johns Hopkins University between Jan. 16 and Mar. 27, are planned especially for undergraduate students and aim to deal with everyday working methods of design, construction and operating rather than with new and striking applications or underlying theory. There are three lectures on each of the three branches of engineering—civil, electrical and mechanical—as given in the following list: Steam-Electric Power Plant Design, by A. S. Loizeaux, Electrical Engineer, Consolidated Gas, Electric Light and Power Co., Baltimore, Md.; The Relation between Civil Engineering and Military Engineering, by Major General William M. Black, Chief of Engineers, U. S. A., Washington, D. C.; The Development of Concrete Road Construction, by Arthur N. Johnson, Consulting Highway Engineer, Portland Cement Association, Chicago, Ill.; Copper Refining, by Edwin Wells Rouse, Jr., Asst. Superintendent, Baltimore Copper Smelting & Rolling Co.; The Coal Problem, by E. G. Bailey, President, Bailey Meter Co., Boston, Mass.; The Growth of Electric Systems, by Julian C. Smith, Vice President, Shawinigan Water and Power Co., Montreal, Canada; The Operation of a Manufacturing Plant, by Ralph E. Thompson, Superintendent, Gillette Safety Razor Co., Boston, Mass.; The Control of Stream Pollution, by Earle B. Phelps, Hygienic Laboratory, American Public Health Service, Washington, D. C.; The Manufacture of Structural Steel, by Bradley Stoughton, Secretary, American Institute of Mining Engineers, New York City. A limited number of copies of this book, bound in heavy paper, are for sale by the publishers.

HOW TO IMPROVE THE HOT-AIR FURNACE

Technical Paper 208, just issued by the Bureau of Mines, Department of the Interior, the author being Charles Whiting Baker. This paper points out certain defects in existing types of hot-air heating plants and suggests a number of improvements in construction and operation that will add to the comfort of the householder and lessen his coal bills. Moreover, the paper deals with a subject that, in spite of its wide interest, has received relatively little attention and is not treated in any other publication of the Bureau. Copies may be obtained free of charge by addressing the Director of the Bureau of Mines, Washington, D. C.

## Obituary

**Charles F. Simms**, for many years manager of the Omaha (Neb.) office of the H. W. Johns-Manville Co., died recently at that place. He had been associated with the company for nearly thirty years and took a large part in the development of its Western enterprises.

## Personals

**S. E. Cole** has succeeded Charles F. Simms, deceased, as manager of the Omaha (Neb.) office of the H. W. Johns-Manville Co.

**Herbert Reynolds**, formerly mechanical assistant to the superintendent of motive power of the United Railways and Electric Co., of Baltimore, Md., has been appointed fuel engineer, United States Bureau of Mines.

**James M. Barry**, engineer of distribution for the Great Western Power Co., of San Francisco, has resigned to become superintendent of the eastern division of the Alabama Power Co., with headquarters at Birmingham.

**E. L. Garrihan**, who has been identified with the manufacturing and sales departments of the Bethlehem Steel Corp. for the last twenty years, has resigned to become manager of sales for the Tioga Steel and Iron Co., of Philadelphia, Penn.

**H. L. Freeman** has been promoted from the post of industrial engineer of the J. G. White Management Corp. to that of manager of the electric department of the Eastern Pennsylvania Railways Co. and the Pennsylvania Light, Heat and Power Co., of Pottsville, Penn. Mr. Freeman was power engineer for a number of years with the Edison Electric Illuminating Co., of Brooklyn.

**I. H. Mills**, who has been associated with the Westinghouse Electric and Manufacturing Co. of East Pittsburgh, Penn., for the last 23 years, has resigned to become superintendent of the Sperry Gyroscope Co., of Brooklyn, N. Y. Mr. Mills began his career with the Westinghouse company as a machine operator, and finally became superintendent of the small industrial motor department.

## Miscellaneous News

**Fire of Uncertain Origin** during the night of Nov. 25 destroyed the main engineering building at the Pennsylvania State College. The building, which was four stories high and about 300 ft. long, contained the power plant for the institution. Much of the county experimental machinery in the building cannot be replaced. More than two-thirds of the mechanical arts exhibit was ruined. The loss is estimated at more than $500,000.

**Maximum Price Fixed for Steam Sizes of Anthracite**—An order of the United States Fuel Administration dated Nov. 16 fixes the maximum price that may be charged for steam sizes of anthracite, as follows: On and after the effective date of this order the maximum prices for the different sizes of anthracite coal below and smaller than the size commonly known as "pea" size, f.o.b. mines, shall not be in excess of the maximum prices established and in force, on the effective date of this order, by Executive Orders of the President and orders of the United States Fuel Administrator for that size of anthracite coal commonly known as "pea" size, less fifty cents ($0.50) per gross ton of 2240 pounds.

## Business Items

**The John A. Stewart Co.**, of Cincinnati, Ohio, dealer in second-hand steam and electrical machinery, has opened an office at 208 South La Salle St., Chicago, Ill.

**The Shepard Electric Crane and Hoist Co.** has opened an office in the New Lexington Building, Baltimore, Md., in order to take care of the rapidly increasing Southern business and to give closer service to users of its apparatus in that territory. This office will be in charge of Norman P. Farrar, who for a number of years has been district manager of the Philadelphia territory.

**Edison Electric Appliance Co., Inc.**, Hotpoint Division, Chicago, Ill., has announced to its distributors and customers that in order to further assist the Government, because of the urgent requests to save paper, it will not distribute this season the special Christmas window decorations or line of coöperative materials. The company states that it will, however, supply its standard line of help in limited quantities.

**New Engineering Firm in New York**—Dwight D. Robinson, a former partner of Stone & Webster in charge of their construction and engineering business, has opened an office in New York under the name of Dwight D. Robinson & Co., Inc., constructing and consulting engineers. Associated with him will be R. M. Henderson, in charge of construction; C. W. E. Clark, mechanical engineer; R. A. Phillips and D. L. Galusha, electrical engineers, and M. E. Thomas, structural engineer, together with the nucleus of a strong purchasing, accounting, and field construction organization. All these men were formerly with the Stone & Webster Engineering Corporation, Boston, Mass.

**Fairbanks, Morse & Co.**, of Chicago, announces the following changes in the management of its business: R. H. Morse has been elected vice president in general charge of purchasing and traffic. He will continue his duties as a director of the company; C. W. Pank rises from general director of sales to vice president in charge of sales of all factory products; W. S. Hovey, formerly general manager of the Fairbanks-Morse Manufacturing plant at Beloit, Wis., has been elected vice president in charge of general manufacturing at all factories; W. E. Miller becomes vice president and treasurer instead of first vice president; F. M. Boughey retires from the position of treasurer to become secretary and comptroller.

## New Construction

### PROPOSED WORK

**Mass., Boston**—The Air Reduction Co., 120 Broadway, New York City, N. Y., will install a steam heating system in the 1-story, 60 x 100 ft. plant which it will build. Total estimated cost, $100,000.

**Mass., New Bedford**—The city will install a steam heating system in the hospital which it plans to build on Mt. Pleasant St. Total estimated cost, $100,000. J. R. Worcester & Co., 79 Milk St., Boston, Engr.

**Mass., State Line**—The New York, New Haven & Hartford R. R., New Haven, Conn., will soon award the contract for the construction of a boiler house, round house, turntable building, etc. Total estimated cost, $80,000. E. Gagle, Ch. Engr.

**N. Y., Brooklyn**—The Board of Education, 500 Park Ave., New York City, will install a steam heating system in the 5 story, 92 x 193 ft. school which it plans to build on Roebling St. Total estimated cost, $600,000.

**N. Y., Brooklyn**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to build extensions to the power plant here. Estimated cost, $175,000. C. W. Parks, Chief.

**N. Y., Buffalo**—The Buffalo Dry Docks Co., Ganson St., has had plans prepared for the construction of a 1-story, 22 x 50 ft. boiler house addition. Noted Nov. 19.

**N. Y., New York**—The Standard Concrete Steel Co., 105 West 40th St., will install a steam heating system in the 1 story, 100 x 225 ft. machine shop which it plans to build on the north side of West 61st St. and Amsterdam Ave. Total estimated cost, $100,000. W. M. Farrar, 105 West 48th St., Arch.

**N. Y., Staten Island**—The Staten Island Ship Building Co., Mariners Harbor, has had plans prepared for the construction of a 1 story, 30 x 90 ft. boiler room. Estimated cost, $10,000. Lockwood, Greene & Co., 101 Park Ave., New York City, Arch.

**N. J., Cape May**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to construct a cold storage building at the section base here; Specification No. 3685. Estimated cost, $50,000.

**N. J., Jersey City**—C. F. Muller, 180 Baldwin Ave., will install a steam heating system in the 2 story, 75 x 150 ft. factory which it plans to build. Total estimated cost, $100,000. John J. Rowland, 100 Sip Ave., Arch.

**N. J., Verona** (Montclair P. O.)—Annin & Co., 99 Fulton St., New York City, N. Y., will install a steam heating system in the 5 story, 60 x 114 ft. factory which it will build on Bloomfield Ave. near Montclair line. Total estimated cost, $150,000.

**Penn., Bethlehem**—The Air Reduction Co., 120 Broadway, New York City, N. Y., will install a steam heating system in the 3-story, 120 x 200 ft. oxygen plant which it will build here. Total estimated cost, $150,000.

**Penn., Philadelphia** — The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to build an extension to the heating system at the U. S. M. C. Reservation here; Specification 3690.

**Penn., Pittsburgh**—The Arsenal Theatre, 4109 Butler St., plans to construct a boiler room. Estimated cost, $2200.

**Del., Wilmington**—The Wilmington Free Institute will install a steam heating system in the 2-story, 90 x 200 ft. library which it plans to build. Total estimated cost, $400,000. E. L. Tilton, 52 Vanderbilt Ave., New York City, N. Y., Arch.

**W. Va., Holden**—The Island Creek Coal Co. is in the market for two 400 hp. boilers for its power plant.

**N. C., Wilmington**—T. D. Mears, City Clerk, will receive bids until Dec. 2 for water-works improvements, including 1,500,000 gallon reinforced concrete sedimentation base, 5,000,000 gallon centrifugal steam-driven pump for raw water, steam-driven turbine engine for double vertical double-acting engine to operate raw water pump, two 20 x 30 ft. additional wings over present station, etc. J. B. Johnson, City Engr.

**S. C., Paris Island**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has had plans drawn for the construction of an addition to power house and heating system here. Estimated cost, $97,000. C. W. Parks, Chief. Noted Nov. 26.

**Ga., Quitman**—The Thomas Elevator Co. will reconstruct its grain elevator which was recently destroyed by fire. Electric motors of 15 to 30 hp. will be installed. W. H. Thomas, Pres.

**La., Oil City**—The Oil City Electric Light & Power Co. will equip an addition to its plant to supply current to nearby towns.

**Ky., Louisville**—Tuck & Co., 1113 West Main St., is in the market for machinery for its power plant.

**Ohio, Cleveland**—The Aluminum Castings Co., 2800 Harvard Ave., will install steam heating systems in the finishing and smelting buildings which it will construct. Total estimated cost, $900,000.

**Ohio, Cleveland**—The Mechanical Rubber Co., Lisbon Rd., plans to build a 2-story, 15 x 75 ft. power house; plans include the construction of a brick substation and transformer house for 4000 k.v.a. Total estimated cost, $15,000. Lockwood Greene Co., 101 Park Ave., New York City, N. Y., Engr.

**Ohio, Cleveland**—The St. Joseph congregation, 15001 Lake Shore Blvd., will install a steam heating system in the 1 story church which it plans to build. Total estimated cost, $100,000.

**Ill., Olney**—The Olney Sanitarium will soon receive bids for remodeling and constructing an addition to its hospital; plans include the construction of a power house, laundry building, etc. Total estimated cost, $250,000. L. H. Osterhage, Second National Bank Building, Vincennes, Ind., Arch.

**Ill., Great Lakes**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for the construction of a temporary power house at the hospital here; Specification No. 3458.

**Iowa, Dodge**—The Minneapolis & St. Louis R. R., Transportation Bldg., Minneapolis, Minn., plans to build terminal buildings here. Project includes the construction of a power house, boiler house, etc. Total estimated cost, $10,000. J. H. Reinholdt, Ch. Engr.

**Wyo., Meeteetse**—The city plans to build a pumping plant, also install a 25 hp. oil-burning engine and single acting triplex pump to handle 150 gallons per minute against 75 lb. pressure.

**Wyo., Torrington**—The city voted $7500 bond issue to improve the electric light plant. Noted Sept. 7.

**Mo., Slater**—The city voted a bond issue of $25,000 for electrical improvements. J. A. Stern, City Clerk.

**Tex., Galveston**—J. J. Kane, 2718 C St., will install boiler works in his plant here.

**Tex., Houston**—The city plans to install pumps, motors, and electrical generators in the central water plant; also change air lift system to centrifugal pump lift. E. E. Sands, City Engr.

**Colo., Ft. Collins**—The city plans a bond issue for the construction of a hydro-electric plant.

**Colo., Hugo**—The Commissioners, Lincoln Co., plan to install an electric light plant in the court house.

**Cal., Los Angeles**—The city plans to construct power plant No. 2 in the San Franciscquito Canyon. Estimated cost, $1,400,000. A. C. Hansen, City Engr.

**Cal., Modesto**—The Waterford Irrigation District plans to install a pumping plant on the Tuolumne River near Waterford to lift water 110 ft. for irrigation of 13,866 acres. Everett N. Bryan, Engr.

**Cal., Redding**—The Northern California Power Co., 905 Market St., San Francisco, plans to extend its line from Coleman on Battle Creek, to a point near Hamilton City, about 54 mi. R. E. Frickey, Engr. Pwr. Station.

**Ont., Guelph**—The Dominion Lines, Ltd., is in the market for a 18 x 80 ft. horizontal tubular boiler.

**Ont., London**—The city is having plans prepared by H. A. Brazier, Engr., for the construction of a power plant. Estimated cost, $46,000.

**Ont., London**—The Peerless Hosiery Co., Adelaide St., will build a 1-story, brick boiler plant. Estimated cost, $8000.

**Ont., West Brantford**—The Consolidated Machine Tool Co. plans to build a boiler house. Estimated cost, $6000.

**B. C., Port Alberni**—The Town Council plans to develop electric power and install a water wheel. Estimated cost, $60,000. R. F. Blandy, City Clerk.

## CONTRACTS AWARDED

**Mass., Boston**—The Linde Air Products Co., 30 East 42nd St., New York City, N. Y., has awarded the contract for the construction of a power house, manufacturing plant, etc., on East 1st St., to J. W. Bishop Co., 863 Atlantic Ave.

**R. I., East Providence**—The American Electric Works, Phillipsdale has awarded the contract for a 1 story 20 x 20 ft. pump house to MacKillop, Inc., Freeman St., Pawtucket. A centrifugal pump will be installed.

**N. Y., Baldwin**—The United States Government, c/o R. C. Marshall, Jr., 7th and B St., S. W., Washington, D. C., has awarded the contract for the construction of a boiler house, store house, etc., to the Austin Co., 217 Broadway, New York City.

**N. Y., Buffalo**—The Monarch Knitting Co., Inc., 19 Doat St., has awarded the contract for the construction of a boiler house and dye house, to R. E. Williams, Iroquois Bldg. Total estimated cost, $22,000. Noted Oct. 8.

**N. Y., Buffalo**—The Worthington Pump & Machinery Corp., Clinton and Roberts St., has awarded the contract for the construction of a 1 story, transformer house, to Henry Harder, 287 Northampton St. Noted Nov. 26.

**N. Y., New York**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a heating and ventilating system in building "E," to S. W. Rittenhouse, 1316 Harvard Ave., Washington, D. C. Estimated cost, $77,824.

**Penn., Nichola**—The Imbrie Coal Co., Butler, has awarded the contract for the construction of a 40 x 65 ft. power house here, to the C. D. Hall Co., 6136 Jenkins Arcade Bldg., Pittsburgh. Estimated cost, $10,000.

**Penn., Altoona**—The Glass Casket Co., Central Trust Bldg., Pittsburgh, will build a factory consisting of 7 buildings; plans include the construction of a power plant, furnace building, etc. Total estimated cost, $500,000. G. H. Mellon, Pres.

**Penn., Mifflin**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a 1 story, 21 x 27 ft. pump house, to the Wark Co., 1737 Filbert St., Philadelphia. Estimated cost, $5000.

**Ohio, Napoleon**—The Detroit, Toledo & Ironton R. R., Boyer Bldg., has awarded the contract for the construction of a 10-stall round house to Crowell, Lundoff & Little Co., 1951 East 57th St., Cleveland. A steam heating system will be installed in same. Total estimated cost, $100,000.

**Ohio, Warren**—The Supreme Motors Co. has awarded the contract for the construction of a 1-story, 200 x 250 ft. factory here, to Crowell, Lundoff & Little Co., 1951 East 57th St., Cleveland. A steam heating system will be installed in same. Total estimated cost, $100,000.

**Ill., Harrisburg**—The Southern Illinois Railway & Power Co. has awarded the contract for the construction of a 25 x 75 ft. addition to its power house, to George Stooleman, Champaign. Estimated cost, $20,000.

**Ill., Pittsfield**—The Board of Supervisors of Pike Co. has awarded the contract for the construction of an electric light plant at the county farm, to R. E. Funk, New Canton.

**Wis., Milwaukee**—The Milwaukee Gas Light Co. has awarded the contract for the construction of a 1-story, 20 x 30 ft. power house, to the Worden-Allen Co., Washington Rd.

# THE COAL MARKET

**Boston**—Current quotations per gross ton f.o.b. mines are as follows:

### ANTHRACITE

| | Circular Current | | Circular Current |
|---|---|---|---|
| Buckwheat | $3.40 | Boiler | $2.35 |
| Rice | 2.90 | Barley | 2.30 |

All-rail rate to Boston is $2.86.

### BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston $8.35 to $8.90.

**New York**—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

| | Circular | Individual | | Circular | Individual |
|---|---|---|---|---|---|
| Pea | $6.55 | $7.30 | Broken | $7.80 | $8.55 |
| Buck. | 5.10 | 5.90 | Egg | 7.70 | 8.45 |
| Rice | 4.65 | 5.10 | Stove | 7.95 | 8.70 |
| Barley | 4.15 | 4.30 | Chestnut | 8.05 | 8.80 |

### BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b. Tidewater, at the lower ports, are as follows:

| | Mine Gross | F.O.B. N.Y. Gross |
|---|---|---|
| Central Pennsylvania (Mine run, Prepared or Slack) | $3.30 | $5.45 |
| Upper Potomac, Cumberland & Piedmont Fields: | | |
| Run of Mine | 3.08 | 5.23 |
| Prepared | 3.36 | 5.51 |
| Slack | 2.80 | 4.95 |

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

**Philadelphia**—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

| | Line | | Tide | |
|---|---|---|---|---|
| | Current | One Yr. Ago | Current | One Yr. Ago |
| Pea | $4.80 | $3.40 | $6.05 | $4.30 |
| Barley | 2.40 | 1.90 | 3.30 | 2.15 |
| Buckwheat | 3.40 | 2.90 | 4.45 | 3.60 |
| Rice | 2.90 | 2.40 | 3.80 | 3.40 |
| Boiler | 2.70 | 2.20 | 3.70 | 3.30 |

**Chicago**—Steam coal prices f.o.b. mines:

| | Illinois Coals | Southern Illinois | Northern Illinois |
|---|---|---|---|
| Prepared sizes | $2.55—2.70 | | $3.25—3.40 |
| Mine-run | 2.35—2.50 | | 3.00—3.15 |
| Screenings | 2.05—2.20 | | 2.75—2.90 |

**Birmingham**—Current prices per net ton f.o.b. mines are as follows:

| | Mine-Run | Prepared Sizes | Slack or Screenings |
|---|---|---|---|
| Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Millidale, Henry Ellen or Acmar | $2.45 | $2.75 | $2.40 |
| Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties | 3.45 | 3.75 | 3.10 |
| Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer | 2.85 | 3.05 | 2.45 |
| Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam | 2.90 | 3.20 | 2.70 |
| Climax seam near Maylene, | | | |

**St. Louis**—Prices per net ton bituminous coal f.o.b. mine today as compared with a year ago are as follows:

| | Williamson and Franklin Counties, Mt. Olive and Staunton | Standard |
|---|---|---|
| Prepared sizes (lump, egg, nut, etc.) | $2.55@2.75 | $2.40@2.70 |
| Mine-run | 2.35@2.50 | 2.20@2.30 |
| Screenings | 2.17@2.32 | 1.50@1.50 |

Williamson-Franklin rate to St. Louis is $1.10.

other rates p. 95.

# PRICES—MATERIALS AND SUPPLIES

**These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.**

## POWER-PLANT SUPPLIES

HOSE—

| | Fire | 50-Ft. Lengths |
|---|---|---|
| Underwriters' 2½-in. | | 85c. per ft. |
| Common, 2½-in. | | 25% |

| | Air | | |
|---|---|---|---|
| | First Grade | Second Grade | Third Grade |
| ¼-in. per ft | $0.65 | $0.40 | $0.30 |

Steam—Discounts from List

First grade..... 15% Second grade.....25% Third grade.....33⅓%

**RUBBER BELTING**—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 50% Best grade..... 30%
Standard..... 40%

Note—Above discounts apply on new list issued July 1.

**LEATHER BELTING**—Present discounts from list in the following cities are as follows:

| | Medium Grade | Heavy Grade |
|---|---|---|
| New York | 40+5% | 35% |
| St. Louis | 30 to 50% | 40% |
| Chicago | 45% | 40% |
| Birmingham | 35% | 35% |
| Denver | 35–5% | 30% |

**RAWHIDE LACING**—40%.

**PACKING**—Prices per pound:

| | |
|---|---|
| Rubber and duck for low-pressure steam | $0.99 |
| Asbestos for high-pressure steam | 1.76 |
| Duck and rubber for piston packing | 1.10 |
| Flax, regular | .99 |
| Flax, waterproofed | 1.21 |
| Compressed asbestos sheet | 1.10 |
| Wire insertion asbestos sheet | 1.32 |
| Rubber sheet | .66 |
| Rubber sheet, wire insertion | .99 |
| Rubber sheet, duck insertion | .55 |
| Rubber sheet, cloth insertion | .25 |
| Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes | 1.21 |
| Asbestos wick, ½- and 1-lb. balls | .75 |

**PIPE AND BOILER COVERING**—Below are discounts and part of standard lists:

| PIPE COVERING | | BLOCKS AND SHEETS | |
|---|---|---|---|
| Pipe Size | Standard List Per Lin.Ft. | Thickness | Price per Sq.Ft. |
| 1-in. | $0.27 | ½-in. | $0.27 |
| 2-in. | .36 | 1 -in. | .30 |
| 6-in. | .80 | 1½-in. | .45 |
| 4-in. | .60 | 2 -in. | .60 |
| 3-in. | .45 | 2½-in. | .75 |
| 8-in. | 1.10 | 3 -in. | .90 |
| 10-in. | 1.30 | 3½-in. | 1.05 |

85% magnesia high pressure..... List

For low-pressure heating and return lines: 4-ply..... 58% off; 3-ply..... 60% off; 2-ply..... 62% off

**GREASES**—Prices are as follows in the following cities in cents per pound for barrel lots:

| | Cincinnati | Pittsburgh | Chicago | St. Louis | Birmingham | Denver |
|---|---|---|---|---|---|---|
| Cup | 7 | 9 | 5½ | 6.9 | 8½ | 12½ |
| Fiber or sponge | 8 | 10 | 6 | 13 | 8½ | 20 |
| Transmission | 7 | 9 | 6 | 13 | 9 | 20 |
| Axle | 4½ | 6 | 4 | 4.1 | 3¾ | 5½ |
| Gear | 4½ | 9 | 4½ | 9.5 | 8 | 9 |
| Car journal | 22(gal.) | 21 (gal.) | 3½ | 4.5 | 5 | 8½ |

**COTTON WASTE**—The following prices are in cents per pound:

| | New York | | Cleveland | Chicago |
|---|---|---|---|---|
| | Current | One Year Ago | | |
| White | 11.00 to 13.00 | 13.00 | 16.50 | 12.00 to 16.50 |
| Colored mixed | 8.50 to 12.00 | 12.00 | 13.00 | 11.50 to 14.00 |

**WIPING CLOTHS**—Jobbers' price per 1000 is as follows:

| | 13¼ x 13½ | 13½ x 20½ |
|---|---|---|
| Cleveland | $52.00 | $58.00 |
| Chicago | 48.00 | 50.00 |

**LINSEED OIL**—These prices are per gallon:

| | New York | | Cleveland | | Chicago | | St. |
|---|---|---|---|---|---|---|---|
| | Current | One Year Ago | Current | One Year Ago | Current | One Year Ago | Louis |
| Raw, in barrel | $1.64 | $1.20 | $1.90 | $1.25 | $1.83 | $1.18 | $1.65 |
| 5-gal. cans | 1.89 | 1.30 | 2.00 | 1.40 | 2.03 | 1.28 | ..... |

**WHITE AND RED LEAD** in 500-lb. lots sell as follows in cents per pound:

| | Red | | | | White | |
|---|---|---|---|---|---|---|
| | Current | | 1 Year Ago | | Current Dry and In Oil | 1 Yr. Ago Dry and In Oil |
| | Dry | In Oil | Dry | In Oil | | |
| 100-lb. keg | 14.00 | 14.50 | 12.25 | 12.50 | 14.00 | 12.00 |
| 15- and 50-lb. kegs | 14.25 | 14.75 | 12.50 | 12.75 | 14.25 | 12.25 |
| 5¼-lb. keg | 14.50 | 15.00 | 12.75 | 13.00 | 14.50 | 12.50 |
| 2 lb. cans | ..... | ..... | 14.25 | 14.00 | 16.00 | 14.50 |
| 1-lb. cans | ..... | ..... | 14.25 | 14.50 | 17.00 | 14.50 |

**RIVETS**—The following quotations are allowed for fair-sized orders from warehouse:

| | New York | Cleveland | Chicago |
|---|---|---|---|
| Steel ½ and smaller | 40% | 45–5% | 45% |
| Tinned | 30% | 45–5% | 45% |

Button heads, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York...$5.675 Cleveland...$5.15 Chicago...$5.67 Pittsburgh...4.65

Coneheads, same sizes:

New York...$5.775 Cleveland...$5.25 Chicago...$5.77 Pittsburgh...$4.75

**REFRACTORIES**—Following prices are f. o. b. works, Pittsburgh:

| | | |
|---|---|---|
| Chrome brick | net ton | $175.00 |
| Chrome cement | net ton | 75.00 |
| Clay brick, 1st quality fireclay | per 1000 | 50.00– 55.00 |
| Clay brick, 2nd quality | per 1000 | 35.00– 40.00 |
| Magnesite, raw | per ton | 30.00– 35.00 |
| Magnesite, calcined | per ton | 32.00– 35.00 |
| Magnesite, dead burned | net ton | 32.00– 35.00 |
| Magnesite brick, 9 x 4½ x 2½ in. | net ton | 110.00–125.00 |
| Silica brick | per 1000 | 50.00– 60.00 |

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $36 to $55.
Birmingham—Fire clay, $50; silica, $50; magnesite, $110; chrome, $165.
Chicago—Second quality, $25 per ton.
Denver—Silica, $35 per 1000.

**BABBITT METAL**—Warehouse prices in cents per pound:

| | New York | | Cleveland | | Chicago | |
|---|---|---|---|---|---|---|
| | Current | One Year Ago | Current | One Year Ago | Current | One Year Ago |
| Best grade | 95.00 | 70.00 | 93.00 | 73.00 | 96.00 | 70.00 |
| Commercial | 50.00 | 40.00 | 23.00 | 22.00 | 25.00 | 25.00 |

**SWEDISH (NORWAY) IRON**—The average price per 100 lb., in ton lots, is:

| | Current | One Year Ago |
|---|---|---|
| New York | $16–19 | $14.00 |
| Cleveland | 20.00 | 15.00 |
| Chicago | 19.00 | 13.00 |

In coils an advance of 50c. usually is charged.
Note—Stock very scarce generally.

**POLES**—Prices on Western red cedar poles:

| | New York | Chicago | Denver | San Francisco |
|---|---|---|---|---|
| 6 in. by 30 ft | $5.82 | $5.17 | $4.55 | $5.17 |
| 7 in. by 30 ft | 7.65 | 6.85 | 6.10 | 6.85 |
| 7 in. by 35 ft | 11.10 | 10.00 | 8.95 | 10.00 |
| 8 in. by 35 ft | 12.65 | 11.35 | 10.10 | 11.35 |
| 7 in. by 40 ft | 12.85 | 11.50 | 10.20 | 11.50 |
| 8 in. by 45 ft | 18.90 | 16.90 | 15.00 | 16.90 |
| 8 in. by 50 ft | 22.65 | 20.30 | 18.00 | 20.30 |

10c. higher freight rates on account of double loads.
For plain pine poles, delivered New York, the price is as follows:

| | |
|---|---|
| 10-in. butts, 5-in. tops, length 20-30 ft | $9.00 |
| 12-in. butts, 6-in. tops, length 30-40 ft | 11.50 |
| 12-in. butts, 6-in. tops, length 41-50 ft | 12.50 |
| 14-in. butts, 6-in. tops, length 51-60 ft | 21.00 |
| 14-in. butts, 6-in. tops, length 61-71 ft | 23.50 |

**PIPE**—The following discounts are for carload lots f. o. b. Pittsburgh, basing card in effect July 2, 1917, for iron, and May 1 for steel:

BUTT WELD

| Steel Black | Galvanized | Inches | Iron Black | Galvanized |
|---|---|---|---|---|
| ¼ to 3 49% | 35½% | ¼ to 1¼ | 33% | 17% |

LAP WELD

| | | | | |
|---|---|---|---|---|
| 2 | 42% | 29½% | 2 | 26% | 12% |
| 2½ to 6 | 45% | 32½% | 2½ to 4 | 28% | 15% |
| 7 to 12 | 42% | 28½% | 4½ to 6 | 28% | 15% |
| 13 and 14 | 32½% | .... | 7 to 8 | 20% | 8% |
| 15 | 30% | .... | | | |

BUTT WELD. EXTRA STRONG PLAIN ENDS

| | | | | |
|---|---|---|---|---|
| ¼ to 1¼ | 47% | 34½% | ¼ to 1¼ | 33% | 18% |
| 2 to 3 | 48% | 35½% | | | |

LAP WELD. EXTRA STRONG PLAIN ENDS

| | | | | |
|---|---|---|---|---|
| 2 | 40% | 28½% | 2 | 27% | 14% |
| 2½ to 4 | 43% | 31½% | 9 to 12 | 15% | 3% |
| 4½ to 6 | 42% | 30½% | 7 to 12 | 25% | 12% |
| 7 to 8 | 38% | 24½% | 2½ to 4 | 29% | 17% |
| 9 to 12 | 33% | 19½% | 4½ to 6 | 28% | 16% |

From warehouses at the places named the following discounts hold for steel pipe:

| | Black | | |
|---|---|---|---|
| | New York | Chicago | St. Louis |
| ¼ to 3 in. butt welded | 40% | 41.1% | 37% |
| 3½ to 6 in. lap welded | 36% | 37.1% | 33% |

| | Galvanized | | |
|---|---|---|---|
| | New York | Chicago | St. Louis |
| ⅛ to 3 in. butt welded | 28% | 26% | 22% |
| 3½ to 6 in. lap welded | 25% | 23% | 19% |

Malleable fittings, Class B and C, from New York stock sell at list +15%. Cast iron, standard sizes, 5% off.

**BOILER TUBES**—The following are the prices for carload lots f.o.b. Pittsburgh, announced Nov. 13, as agreed upon by manufacturers and the Government:

| Lap Welded Steel | | Charcoal Iron | |
|---|---|---|---|
| 3½ to 4½ in. | 34 | 3½ to 4½ in. | 12½ |
| 2½ to 3¼ in. | 24 | 3 to 3¼ in. | + 5 |
| 2¼ in. | 17½ | 2½ to 2¾ in. | + 7½ |
| 1¼ to 2 in. | 13 | 2 to 2¼ in. | +22½ |
| | | 1⅞ to 1⅞ in. | +35 |

Standard Commercial Seamless—Cold drawn or hot rolled

| | Per Net Ton | | Per Net Ton |
|---|---|---|---|
| 1 in. | $340 | 1¾ in. | $220 |
| 1¼ in. | 280 | 2 to 2½ in. | 190 |
| 1½ in. | 270 | 2¾ to 3½ in. | 180 |
| 1¾ in. | 220 | 4 in. | 200 |
| | | 4½ to 5 in. | 220 |

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation.

# ELECTRICAL SUPPLIES

**ARMORED CABLE**—

| B.&S. Size | Two Cond. M Ft. | Three Cond. M Ft. | Two Cond. Lead M Ft. | Three Cond. Lead M Ft. |
|---|---|---|---|---|
| No. 14 solid | $104.00 | $138.00 | $164.00 | $222.00 |
| No. 12 solid | 135.00 | 170.00 | 211.00 | 290.00 |
| No. 10 solid | 185.00 | 235.00 | 255.00 | 325.00 |
| No. 8 stranded | 235.00 | 325.00 | 345.00 | 450.00 |
| No. 6 stranded | 370.00 | 472.00 | 625.00 | ..... |

From the above lists discounts are:

| | Net List |
|---|---|
| Less than coil lots | |
| Coils to 1,000 ft. | 10% |
| 1,000 ft. and over | 15% |

**BATTERIES, DRY**—Regular No. 6 size red seal, Columbia, or Ever Ready:

| | Each, Net |
|---|---|
| Less than 12 | $0.40 |
| 12 to 50 | .38 |
| 50 to 125 (bbl.) | .35 |
| 125 (bbl.) or over | .32 |

**CONDUITS, ELBOWS AND COUPLINGS**—Following are warehouse net prices per 1000 ft. for conduit and per 100 for couplings and elbows:

| | Conduit | | Elbows | | Couplings | |
|---|---|---|---|---|---|---|
| Size, In. | Black 1,000 Ft. and Over | Galvanized 1,000 Ft. and Over | Black 100 and Over | Galvanized 100 and Over | Black 100 and Over | Galvanized 100 and Over |
| ⅜ | ..... | ..... | $18.24 | $19.38 | $5.76 | $6.12 |
| ½ | $76.50 | $81.60 | 18.24 | 19.38 | 6.72 | 7.14 |
| ¾ | 101.20 | 108.10 | 24.00 | 25.50 | 9.60 | 10.20 |
| 1 | 149.60 | 159.80 | 35.52 | 37.74 | 12.48 | 13.26 |
| 1¼ | 202.40 | 216.20 | 45.45 | 48.15 | 17.17 | 18.19 |
| 1½ | 242.00 | 258.50 | 60.60 | 64.20 | 21.21 | 22.47 |
| 2 | 325.60 | 347.80 | 111.11 | 117.70 | 28.28 | 29.96 |
| 2½ | 514.80 | 549.90 | 181.80 | 192.60 | 40.40 | 42.80 |
| 3 | 673.20 | 719.10 | 484.80 | 513.60 | 60.60 | 64.20 |
| 3½ | 837.20 | 892.40 | 1,070.60 | 1,134.20 | 80.80 | 85.60 |
| 4 | 1,013.70 | 1,079.10 | 1,237.25 | 1,310.75 | 101.00 | 107.00 |

5% cash 10 days.

From New York Warehouse—Less 5% cash.

Standard lengths rigid, 10 ft. Standard lengths flexible, ⅜ in., 100 ft. Standard lengths flexible, ½ to 2 in., 50 ft.

**CONDUIT NON-METALLIC, LOOM**—

| Size I. D., In. | Feet per Coil | List, Ft. | |
|---|---|---|---|
| ⅜ | 250 | $0.05½ | Coils...45% Off.. Less coils, 30% off |
| ½ | 250 | .06 | |
| ¾ | 250 | .09 | |
| ¾ | 200 | .12 | |
| 1 | 200 | .15 | |
| 1 | 150 | .18 | |
| 1 | 100 | .25 | |
| 1¼ | 100 | .33 | |
| 1½ | Odd lengths | .40 | |
| 2 | Odd lengths | .55 | |

**CUT-OUTS**—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

| | | | |
|---|---|---|---|
| S. P. M. L. | $0.11 | T. P. to D. P. S. B. | $0.24 |
| D. P. M. L. | .18 | T. P. to D. P. T. B. | .38 |
| T. P. M. L. | .26 | T. P. S. B. | .33 |
| D. P. S. B. | .19 | T. P. D. B. | .54 |
| D. P. D. B. | .37 | | |

CUT-OUTS, N. E. C. FUSE

| | 0-30 Amp. | 31-60 Amp. | 60-100 Amp. |
|---|---|---|---|
| D. P. M. L. | $0.33 | $0.84 | $1.68 |
| T. P. M. L. | .48 | 1.20 | 2.40 |
| D. P. S. B. | .42 | 1.05 | .... |
| T. P. S. B. | .81 | 1.80 | .... |
| D. P. D. B. | .78 | 2.10 | .... |
| T. P. D. B. | 1.35 | 3.60 | .... |
| T. P. to D. P. D. B. | .90 | 2.52 | .... |

**FLEXIBLE CORD**—Price per 1000 ft. in coils of 250 ft.:

| | |
|---|---|
| No. 18 cotton twisted | $22.00 |
| No. 16 cotton twisted | 28.40 |
| No. 18 cotton parallel | 25.00 |
| No. 16 cotton parallel | 32.00 |
| No. 18 cotton reinforced heavy | 35.00 |
| No. 16 cotton reinforced heavy | 42.00 |
| No. 18 cotton reinforced light | 30.00 |
| No. 16 cotton reinforced light | 36.00 |
| No. 18 cotton Canvasite cord | 29.00 |
| No. 16 cotton Canvasite cord | 35.00 |

**FUSES, ENCLOSED**—

| 250-Volt | Std. Pkg. | List |
|---|---|---|
| 3-amp. to 30-amp. | 100 | $0.25 |
| 35-amp. to 60-amp. | 100 | .35 |
| 65-amp. to 100-amp. | 50 | .90 |
| 110-amp. to 200-amp. | 25 | 2.00 |
| 225-amp. to 400-amp. | 25 | 3.60 |
| 450-amp. to 600-amp. | 10 | 5.50 |

| 600-Volt | Std. Pkg. | List |
|---|---|---|
| 3-amp. to 30-amp. | 100 | .40 |
| 35-amp. to 60-amp. | 100 | .60 |
| 65-amp. to 100-amp. | 50 | 1.50 |
| 110-amp. to 200-amp. | 25 | 2.50 |
| 225-amp. to 400-amp. | 25 | 5.50 |
| 450-amp. to 600-amp. | 10 | 8.00 |
| Discount: Less 1-5th standard package | 30% | |
| 1-5th to standard package | 40% | |
| Standard package | 52% | |

**FUSE PLUGS, MICA CAP**—

| | |
|---|---|
| 0-30 ampere, standard package | $5.25 C |
| 0-30 ampere, less than standard package | 7.00 C |

**LAMPS**—Below are present quotations in less than standard package quantities:

| Straight-Side Bulbs | | | | Pear-Shape Bulbs | | | |
|---|---|---|---|---|---|---|---|
| Mazda B— Watts | Plain | Frosted | No. in Package | Mazda C— Watts | Clear | Frosted | No. in Package |
| 10 | $0.35 | $0.38 | 100 | 75 | $0.70 | $0.75 | 50 |
| 15 | .35 | .38 | 100 | 100 | 1.10 | 1.15 | 24 |
| 25 | .35 | .38 | 100 | 150 | 1.65 | 1.70 | 24 |
| 40 | .35 | .38 | 100 | 200 | 2.20 | 2.27 | 24 |
| 50 | .35 | .38 | 100 | 300 | 3.25 | 3.35 | 24 |
| 60 | .40 | .45 | 100 | 400 | 4.30 | 4.45 | 12 |
| 100 | .85 | .92 | 24 | 500 | 4.70 | 4.85 | 12 |
| | | | | 750 | 6.50 | 6.75 | 8 |
| | | | | 1000 | 7.50 | 7.75 | 8 |

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

**PLUGS, ATTACHMENT**—

| | Each |
|---|---|
| Hubbell, porcelain No. 5406, standard package 250 | $0.24 |
| Hubbell composition No. 5467, standard package 50 | .32 |
| Benjamin swivel No. 903, standard package 250 | .20 |
| Hubbell current taps No. 5638, standard package 50 | .40 |

**RUBBER-COVERED COPPER WIRE**—Per 1000 ft. in New York:

| No. | Solid Single Braid | Solid Double Braid | Stranded, Double Braid | Duplex |
|---|---|---|---|---|
| 14 | $13.00 | $16.00 | $18.00 | $32.00 |
| 12 | 16.70 | 18.80 | 22.00 | 36.85 |
| 10 | 23.52 | 26.10 | 29.10 | 50.60 |
| 8 | 31.00 | 36.40 | 40.20 | 70.10 |
| 6 | ..... | ..... | 62.00 | ..... |
| 4 | ..... | ..... | 83.10 | ..... |
| 2 | ..... | ..... | 122.40 | ..... |
| 1 | ..... | ..... | 161.30 | ..... |
| 0 | ..... | ..... | 189.68 | ..... |
| 00 | ..... | ..... | 230.00 | ..... |
| 000 | ..... | ..... | 282.40 | ..... |
| 0000 | ..... | ..... | 345.50 | ..... |

**Prices per 1000 ft. for Rubber-covered Wire in Following Cities:**

| | Denver | | | St. Louis | | | Birmingham | | |
|---|---|---|---|---|---|---|---|---|---|
| No. | Single Braid | Double Braid | Duplex | Single Braid | Double Braid | Duplex | Single Braid | Double Braid | Duplex |
| 14 | $17.00 | $21.00 | $39.40 | $21.00 | $16.00 | $33.00 | $13.00 | $17.40 | $36.80 |
| 10 | 25.65 | 28.90 | 64.75 | 27.20 | 31.00 | 69.00 | 21.40 | 24.40 | 42.75 |
| 8 | 36.45 | 40.25 | 88.45 | 38.00 | 42.00 | 78.00 | 42.35 | 44.35 | ..... |
| 6 | 57.40 | 61.70 | ..... | ..... | 65.00 | 130.00 | 64.60 | 74.60 | ..... |
| 4 | 83.40 | 88.70 | ..... | ..... | 93.00 | ..... | 101.75 | 106.05 | ..... |
| 2 | 126.60 | 132.80 | ..... | ..... | 140.00 | ..... | 151.50 | ..... | ..... |
| 1 | 164.15 | 172.40 | ..... | ..... | 182.00 | ..... | 201.00 | 258.50 | ..... |
| 0 | ..... | 206.80 | ..... | ..... | 242.00 | ..... | 276.00 | 285.00 | ..... |
| 00 | ..... | 278.80 | ..... | ..... | 290.00 | ..... | 317.00 | 330.00 | ..... |
| 000 | ..... | 341.65 | ..... | ..... | 360.00 | ..... | 417.00 | 428.50 | ..... |
| 0000 | ..... | 417.05 | ..... | ..... | 435.00 | ..... | 516.00 | 516.00 | ..... |

Pittsburg—34c. base; discount 50%

**SOCKETS, BRASS SHELL**—

| ⅛ In. or Pendant Cap. | | | ¼ In. Cap | | |
|---|---|---|---|---|---|
| Key, Each | Keyless, Each | Pull, Each | Key, Each | Keyless, Each | Pull, Each |
| $0.33 | $0.30 | $0.60 | $0.39 | $0.36 | $0.66 |

| | |
|---|---|
| Less 1-5th standard package | +20% |
| 1-5th to standard package | +10% |
| Standard package | −15% |

**WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE**—

| | |
|---|---|
| No. 18 B.&S. regular spools (approx. 8 lb.) | 50c. lb. |
| No. 18 B.&S. regular 1-lb. coils | 52c. lb. |

**WIRING SUPPLIES**—

| | |
|---|---|
| Friction tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots | 48c. lb. |
| Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots | 60c. lb. |
| Wire solder, less 100 lb. 50c. lb., 100 lb. lots | 46c. lb. |
| Soldering paste, 2 oz. cans Nokorode | $1.20 doz. |

**SWITCHES, KNIFE**—

TYPE "C" NOT FUSIBLE

| Size, Amp. | Single Pole, Each | Double Pole, Each | Three Pole, Each | Four Pole Each |
|---|---|---|---|---|
| 30 | $0.42 | $0.68 | $1.02 | $1.36 |
| 60 | .74 | 1.22 | 1.84 | 2.44 |
| 100 | 1.50 | 2.50 | 3.76 | 5.00 |
| 200 | 2.70 | 4.50 | 6.76 | 9.00 |

TYPE "C" FUSIBLE, TOP OR BOTTOM

| | | | | |
|---|---|---|---|---|
| 30 | .70 | 1.06 | 1.60 | 2.12 |
| 60 | 1.18 | 1.80 | 2.70 | 3.60 |
| 100 | 2.38 | 3.66 | 5.50 | 7.30 |
| 200 | 4.40 | 6.76 | 10.14 | 13.50 |

Discounts:

| | |
|---|---|
| Less than $10.00 list value | + 5% |
| $10 to $25 list value | — 8% |
| $25 to $50 list value | —15% |
| $50 to $200 list value | —20% |
| $200 list value or over | —25% |